The Effects of Hysterectomy on Sexual Arousal in Women With a History of Benign Uterine Fibroids

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Research indicates hysterectomy surgery may adversely affect the pelvic autonomic nerves and autonomic mechanisms are integral to the sexual arousal response in women. This study explored the possibility that women who undergo hysterectomy may experience an impaired vasocongestive response to erotic stimulation. Thirty-two women with a history of benign uterine fibroids who had ($n = 15$) or had not ($n = 17$) undergone hysterectomy participated in two experimental sessions in which self-report and physiological (vaginal pulse amplitude; VPA) sexual responses were recorded during an erotic film presentation. In one of the sessions, the women exercised on a treadmill for 20 min prior to viewing the erotic films as a means inducing autonomic arousal. Exercise significantly increased VPA but not subjective sexual responses in both groups of women. VPA responses were marginally higher among the fibroid than hysterectomy group in the no-exercise condition. The hypothesis that physiological sexual arousal may be impaired with hysterectomy surgery was only partially supported.

KEY WORDS: hysterectomy; uterine fibroids; sexual arousal; exercise; vaginal photoplethysmography.

INTRODUCTION

Hysterectomy is the most common nonpregnancy-related surgery performed among American women. About 600,000 women undergo this procedure each year in the United States, and by the age of 60 nearly one out of every three American women will have undergone hysterectomy (Easterday & Grimes, 1983; Lepine et al., 1997; Wilcox et al., 1994). Approximately 90% of hysterectomies are conducted for benign conditions such as leiomyomas (fibroids), dysfunctional uterine bleeding, endometriosis, chronic pelvic pain, and prolapse (Pokras & Hufnagel, 1987). Reports of positive outcomes posthysterectomy include the cessation of abnormal uterine bleeding, relief from menstrual symptoms and pelvic pain, and decreases in depression and anxiety (for review, see Farquhar et al., 2002). A high proportion of women, however, develop new symptoms posthysterectomy which include depression, fatigue, urinary incontinence, constipation, early ovarian failure, and sexual dysfunction

(e.g., Carlson, Miller, & Fowler, 1994; Thakar, Manyonda, Stanton, Clarkson, & Robinson, 1997). In one retrospective study of women at a minimum of 2 years posthysterectomy, at least half reported symptoms caused or worsened by hysterectomy (Bachmann, 1990). Thus, it is not surprising that concern has been raised regarding the appropriateness of this surgery for the treatment of nonmalignant conditions. Nerve-sparing surgical techniques and procedures, such as endometrial ablation and supracervical hysterectomy, are offered as alternatives to total hysterectomy for the treatment of benign conditions but, as of yet, they have not substantially impacted hysterectomy rates (Farquhar & Steiner, 2002).

The extent to which hysterectomy impacts sexual function is of debate in the literature. Studies have estimated anywhere from 4% (Schofield, Bennett, Redman, Walters, & Sanson-Fisher, 1991) to 40% (Carranza-Lira, Murillo-Uribe, Trejo, & Santos-Gonzalez, 1997) of women report decreases in sexual desire, and between 8% (Eicher, 1994) and 25% (Dennerstein, Wood, & Burrows, 1977) of women report decreased orgasmic ability posthysterectomy. Other studies have concluded that hysterectomy has a largely positive impact on the sex

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lives of women (e.g., Rhodes, Kjerulff, Langenberg, & Guzinski, 1999; Schofield et al., 1991), and that sexual desire and orgasm are most likely either unchanged or enhanced following surgery (e.g., Coppen, Bishop, Barnard, & Collins, 1981; Ewert, Slangen, & Van Herendael, 1995).

To date, information on the relation between hysterectomy and sexual function is based almost exclusively on self-report measures. Retrospective questionnaire studies are prone to recall biases and cannot account for the effects of preoperative sexual functioning on postoperative assessment. Prospective studies that assess sexual functioning pre- and posthysterectomy are complicated by the fact that baseline sexuality data are generally collected just prior to surgery when the woman is likely to be experiencing decreased sexual interest due to anxieties about the upcoming surgery (e.g., Carlson et al., 1994; Rhodes et al., 1999). For women who undergo hysterectomy to treat benign uterine fibroids, presurgery sexual function may also be influenced by excessive menstrual bleeding and consequent anemia, pain with sexual activity, and treatment with gonadotrophin releasing hormone (GnRH) agonists which have been reported to cause side effects such as vaginal dryness and decreased libido (Auber et al., 1990; Brogden, Buckley, & Ward, 1990; Chrisp & Goa, 1990). Moreover, many studies assess sexual functioning as early as 6 months posthysterectomy while evidence suggests that the effect of surgery on sexuality, whether positive or negative, evolves gradually, and that the follow-up should occur at least 12 months after surgery (for review, see Farrell & Kieser, 2000). Differences in factors such as age, relationship with partner, hormonal effects (i.e., hormone replacement therapy, oophorectomy), psychological well-being (i.e., anxiety, depression), indication for surgery (fibroids, menstrual disorders, cancer), and type of surgery could also help explain the discrepancy between findings from self-report studies.

Also, limiting to the understanding of how hysterectomy impacts sexuality is the fact that most studies have failed to use validated measures of sexual functioning and do not provide justification for how or what they are assessing. For example, the Maryland Women's Health Study (Rhodes et al., 1999), a prospective survey of over 1,200 women, concluded that sexual functioning improved overall after hysterectomy. Rhodes et al. based these conclusions, in part, on the finding that frequency of "sexual relations" increased posthysterectomy and stated that

> Increased sexual activity after hysterectomy may be the strongest evidence of a positive effect of hysterectomy on sexual functioning. This is because improved sexual functioning and increased sexual enjoyment are the most obvious explanations for increased sexual relations after hysterectomy. (pp. 1938–1939)

This conclusion seems overstated in light of a number of factors. First, Rhodes et al. did not define whether "sexual relations" referred specifically to intercourse or whether it also included behaviors such as masturbation, kissing, and petting. For some women, frequency of intercourse may be a better indicator of partner availability and drive than their own sexual enjoyment or desire. Second, Rhodes et al. did not assess sexual enjoyment either prior to or following hysterectomy and provided no evidence to suggest a link between increased "sexual relations" and sexual pleasure. Third, a significant proportion of women in the study reported decreases in sexual pain following hysterectomy. If sex was no longer painful, the women may have been more willing to engage in sexual activity and this could account for the increases in sexual activity also noted posthysterectomy. Of course willingness to engage in sexual activity and sexual pleasure are not necessarily linked.

Another limitation to the understanding of how hysterectomy impacts sexual function is that studies have focused almost exclusively on measures of sexual desire and orgasm and, to a lesser extent, sexual satisfaction. With one exception, sexual arousal has been discussed only in studies that have examined women who have undergone oophorectomy (e.g., Dennerstein et al., 1977; Weber, Walters, Schover, Church, & Piedmonte, 1999). This is surprising given that sexual arousal, as defined in the *DSM-IV-TR* (American Psychiatric Association, 2000), pertains specifically to a genital response and hysterectomy is an operation that focuses primarily on the genitalia.

In the one previous study that examined physiological sexual arousal in women who had undergone hysterectomy (Bellerose & Binik, 1993), comparisons of vaginal pulse amplitude (VPA) responses to erotic stimuli were made between five groups of women: those who had undergone hysterectomy but maintained at least one ovary ($n = 15$), three groups of women who had undergone hysterectomy plus bilateral salpingo-oophorectomy (those on estrogen replacement therapy ($n = 15$), those on androgen–estrogen therapy ($n = 8$), and those not on hormone replacement therapy ($n = 5$)), and a group of nonsurgical control women ($n = 15$). The women participated in two sessions: an interview/questionnaire session and a session that measured subjective and VPA responses to erotic films. No significant group differences were found on physiological measures of sexual arousal. Although these findings provide important information on the sexual responses of hysterectomized women, they are limited in that the single VPA assessment session allowed for only between-group comparisons. It has been argued that, given the inability to calibrate VPA and the wide variability in VPA responses between women, it is questionable whether VPA data should be used in between-group

comparisons, particularly in studies with small sample sizes (e.g., Janssen, 2002).

This study examined subjective and physiological sexual arousal processes in women with a history of benign uterine fibroids who had or had not undergone hysterectomy. The women participated in two experimental sessions in which self-report and physiological (VPA) sexual responses were recorded during an erotic film presentation. In one of the sessions, the women exercised on a treadmill for 20 min at 70% of their maximum heart rate (HR_{max})[2] prior to viewing the erotic films. In a series of studies conducted in nonhysterectomized, sexually functional women, Meston and Gorzalka (1995, 1996a, 1996b) found that exercise at the duration and intensity employed here significantly enhanced VPA responses to erotic films. It could not be determined from these studies whether the increases in VPA postexercise were attributable to increased sympathetic nervous system activity, parasympathetic nervous system activity, or an interaction between the two. Regardless, the findings are congruent with a body of literature indicating an important role of autonomic arousal in the female sexual physiological arousal response (for review, see Giuliano, Rampin, & Allard, 2002).

The autonomic nerves of the female internal genital organs are thought to be supplied via the superior hypogastric plexus, which divides and eventually forms the inferior hypogastric plexuses. The inferior hypogastric plexus extends into the left and right cardinal and uterosacral ligaments. Hysterectomy may affect the pelvic autonomic nerves through excision of the cervix and separation of the uterus from the cardinal and uterosacral ligaments (Thakar et al., 1997). If sexual arousal processes are negatively impacted by hysterectomy surgery, and this is associated with impaired autonomic innervation, differences between women who have and have not undergone hysterectomy would be expected to emerge under conditions of heightened autonomic arousal. This study extends previous research on hysterectomy and sexual function by: (1) examining sexual arousal processes under conditions of heightened autonomic arousal, (2) making within-subject comparisons of physiological and subjective sexual arousal, (3) examining self-report measures of sexual function using an inventory that has been validated on sexually dysfunctional women, and (4) using a control group that matches the hysterectomy group on history of benign uterine fibroids—the most common indication for hysterectomy.

METHOD

Participants

Participants were obtained through referrals from the Renaissance Women's Medical Clinic, via advertisements in the local and University of Texas newspapers, and via posters placed in women's restrooms across the University of Texas campus. The advertisements called for women to participate in a study directed toward understanding the effects of hysterectomy and uterine fibroids on sexual function.

The final total sample size was 32: 15 women who had and 17 women who had not received hysterectomy surgery. Inclusion criteria for all participants were: over age 20, premenopausal (as determined by assays assessing FSH and estradiol), heterosexual, absence of vaginal disease, and currently involved in a sexually active relationship. Participants who met the initial criteria were given a clinical interview via telephone and were excluded from participation if they met criteria for a *DSM-IV* Axis I disorder, including organic mental syndromes and disorders, schizophrenia, delusional disorder or psychotic disorders not classified elsewhere, or if they were at risk for suicide ($n = 0$). Patients who were currently receiving any medications known to affect vascular or sexual functioning (including antidepressants, antihypertensives) were excluded from participation ($n = 2$). Individuals previously on medications known to affect vascular or sexual functioning were required to have a 3-week wash-out period prior to participation.

Further inclusion criteria for women who had undergone hysterectomy (experimental group) were: having undergone hysterectomy for the primary purpose of treating benign uterine fibroids no less than 1 year and no more than 10 years prior, and at least one intact ovary. This latter criterion was used because bilateral oophorectomy and the consequent decrease in ovarian hormones may adversely impact sexual function by, for example, decreasing vaginal lubrication (e.g., Dennerstein et al., 1977) or compromising a woman's sexual attractiveness via destruction of axillary pheromonal secretions (Cutler,

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[2]Participants were asked to run at a constant target heart rate (70% HR_{max}, determined using Karvonen's formula (American College of Sports Medicine, 1995). HR_{max} is an indirect assessment of the maximal volume of oxygen one can consume during exhausting work, and is closely linked to aerobic fitness levels (e.g., Sutton, 1992). HR_{max} was used as a criterion for exercise intensity, rather than an absolute criterion (e.g., a specific length of running time) to ensure that participants of potentially different fitness levels exercised at comparable levels of exertion. Fitness levels were not assessed because Meston and Gorzalka (1995) reported no correlation between fitness levels and physiological measures of sexual arousal when participants exercised at equivalent levels of their HR_{max}.

1996). One woman was excluded from participation because she had had both ovaries removed. Further inclusion criteria for women who had not undergone hysterectomy (fibroid group) were: diagnosis of benign uterine fibroids as per ultrasonography screening, and not scheduled or planning for hysterectomy surgery. This latter criterion was used because it may be expected that upcoming gynecological surgery would create a certain degree of anxiety, fear, and concern for the woman involved, and subsequently might adversely impact sexual function. Women who were currently receiving treatment for uterine fibroids with GnRH agonists (e.g., Goserelin acetate, Nafarelin, Buserelin) were excluded from participation ($n = 0$). Thirty-four premenopausal women with a history of benign uterine fibroids met initial inclusion criteria and were scheduled for their medical screening visit at the Renaissance Women's Medical Clinic. Seventeen of these women had undergone hysterectomy for the treatment of benign uterine fibroids; 17 had not undergone hysterectomy.

There were no significant differences between the hysterectomy and fibroid groups on age, weight, race, education, marital status, length of relationship, marital satisfaction, body satisfaction, or depression (see Table I). All women were premenopausal; none of the women were on hormone replacement therapy.

For women in the fibroid group, the average length of time that they had been diagnosed with benign uterine fibroids was 4 years (range, 2 months–11 years). The mean number of fibroids detected upon ultrasound screening was 3 (range, 1–7) and the mean size of the largest fibroid was 48 mm. None of the women in this group reported having undergone any procedure for fibroid removal. Among the women in the hysterectomy group, the average length of time since hysterectomy surgery was 3 years, 8 months (range, 13 months–10 years). All but two of the women had both ovaries intact; two women had received unilateral oophorectomies. Seven women had received an abdominal hysterectomy and seven women received a vaginal hysterectomy. Of these women, nine had undergone subtotal hysterectomy and five had undergone total hysterectomy. Data on these two variables were missing for one woman.

Procedure

Session 1 (Medical Screening)

During this session, the participants signed the informed consent document and were given a chance to ask any questions. A registered nurse then conducted a brief

Table I. Participant Characteristics

	Hysterectomy ($N = 15$)	Fibroid ($N = 17$)
Age		
Mean (*SEM*)	41.4 (0.86)	40.0 (0.99)
Range	36–46	35–49
Weight (pounds)		
Mean (*SEM*)	149 (17.6)	169 (14.98)
Race (%)		
Caucasian	11 (73)	12 (71)
Other	4 (27)	5 (29)
Education (%)		
High school graduate or less	1 (7)	1 (6)
Some college–2 year degree	9 (60)	7 (41)
4 year degree	4 (27)	1 (6)
Advanced degree	1 (7)	8 (47)
Marital status (%)		
Single	1 (7)	4 (24)
Married	10 (67)	8 (47)
Divorced	4 (27)	5 (29)
Length of relationship (%)		
0–6 months	0 (0)	1 (6)
6 months–10 years	7 (47)	12 (71)
>10 years	8 (53)	4 (24)
Locke–Wallace Marital Adjustment Test		
Mean (*SEM*)	105 (1.00)	95 (7.67)
Body Satisfaction Scale		
Mean (*SEM*)	19.8 (1.24)	22.0 (2.15)
Beck Depression Inventory		
Mean (*SEM*)	8.0 (2.7)	7.1 (1.51)
Range	0–32	1–23
Female Sexual Function Index		
Desire Mean (*SEM*)	6.5 (0.56)	6.2 (0.52)
Arousal Mean (*SEM*)	14.7 (1.51)	14.5 (1.67)
Lubrication Mean (*SEM*)	15.2 (1.63)	16.2 (1.33)
Orgasm Mean (*SEM*)	12.0 (1.12)	11.6 (1.06)
Satisfaction Mean (*SEM*)	10.4 (1.01)	10.5 (0.91)
Pain Mean (*SEM*)	12.9 (1.14)	10.6 (1.40)
Index of Sexual Satisfaction Mean (*SEM*)	131 (4.0)	129 (3.21)

cardiovascular exam to ensure the women would not be at risk when exercising. None of the women were considered at risk. Blood samples were drawn so that analyses of FSH and estradiol could be made. Because menopause is likely to affect sexuality, information on these hormone levels allowed for the identification of women who were within this transitional period. Participants were then administered a demographics questionnaire, a medical history questionnaire, the Beck Depression Inventory (BDI; Beck & Beamesderfer, 1974), the Index of Sexual Satisfaction (Hudson, Harrison, & Crosscup, 1981), the Marital Adjustment Test (Locke & Wallace, 1959), the Female Sexual Function Index (FSFI; Rosen et al., 2000), and the Body Satisfaction Scale (Stice, Nemeroff, & Shaw, 1996). They were then given a complete physical exam, including

pap. Those women who had not received hysterectomy surgery were also given a pelvic ultrasound to validate and further assess their degree of uterine fibroids. The gynecologists screened the women for vaginal atrophy, vaginal scarring or surgical damage, significant cervicitis, and cervical dysplasia. Following the examination period, participants were given a 4-week supply of Daily Diary questionnaires along with four self-addressed, stamped envelopes. The diaries monitored the daily frequency of intimate contacts, masturbation, sexual intercourse, and sexual thoughts. They were instructed to fill out one form each day and mail in the forms at the end of each week. Before leaving their first session, participants were scheduled for their first psychophysiological test session (second session), which was approximately 4 weeks from the date of their first session, on a day when they (fibroid group) were not menstruating.

Two of the women who had undergone hysterectomy were terminated from the study after the medical screening. One of these women was excluded because the results from her physical examination indicated an abnormal pap with severe dysplasia. She was referred to a gynecologist for follow-up and paid for her participation. The second woman was terminated from further participation because she failed to complete or mail in the required daily diary forms prior to her psychophysiological session.

Sessions 2 and 3 (Psychophysiology)

The second and third sessions were the two experimental conditions: no-exercise and exercise. Order of these conditions was counterbalanced across participants. For both of these sessions, the participants were asked to abstain from caffeine and alcohol, and to refrain from engaging in any strenuous physical activity for 24 hr prior to their visit. These sessions were conducted at the Female Sexual Psychophysiology Laboratory at the University of Texas at Austin. This laboratory has an adjoining, private, internally locked participant room. An intercom system between the participant and experimenter rooms allows for communication with participants at all times. A 27-in. color television monitor is positioned at a distance that allows participants to sit comfortably in a recliner with a full view of the screen. A treadmill is positioned to the rear of the room.

During the no-exercise condition, participants entered the private, internally locked room together with the female experimenter. They were told that once the experimenter left the room, they were to sit in the chair and insert the vaginal photoplethysmograph using a placement device that standardizes the distance of probe insertion

between women. To minimize potential movement artifacts, participants were asked to remain as still as possible throughout the session. When participants notified the experimenter, via the intercom system, that they had finished inserting the plethysmograph, a 10-min adaptation recording was taken. After the adaptation period, participants viewed either videotaped sequence A or B. Each sequence consisted of the word "relax" (1 min), a neutral travelogue (3 min), and an erotic film (5 min). The films depicted a hetereosexual couple engaging in foreplay and intercourse and were matched on the number and type of sexual activities. Immediately after the erotic film, participants were asked to fill out a subjective sexual arousal rating scale.

During the exercise condition, participants entered the room with the female experimenter and were informed of the experimental procedures as in the no-exercise condition. They were then asked to run for 20 min on a treadmill, during which time their HR was monitored continuously. Respondents were given continual visual feedback on their HR levels, and were asked to run faster or slower if their HR indicated that they were below or above 70% of their HR_{max}.

When 1 min of exercise time remained, the experimenter left the room. Participants were instructed to continue running until the timer signaled 20 min and then to sit in the chair, insert the plethysmograph, and notify the experimenter (via the intercom system) when they were ready. When the experimenter was notified, a 10-min adaptation recording was taken, followed immediately by one of the videotaped sequences (A or B). The total time from the cessation of exercise to the onset of the erotic stimulus was approximately 15 min (1 min to insert the plethysmograph, 10-min adaptation period, 1 min display of the word *relax*, 3-min neutral film) for all groups. Immediately after watching the erotic film, participants were asked to fill out the subjective rating scale. With the exception of 20 min of running, all experimental procedures were identical to those of the no-exercise condition.

After completing Session 3, participants were thoroughly debriefed, informed about the additional purposes and goals of the study, and given an opportunity to view the records of their vaginal responses. The study was approved by the ethics committee at the University of Texas.

Self-Report Measures

Locke–Wallace Marital Adjustment Test

The Locke–Wallace Marital Adjustment Test is a 15-item self-report measure of marital satisfaction or quality,

as well as agreement/disagreement on a number of issues (finances, recreation, affection, friends, sex, conventionality, conflict resolution, and confiding). Scores range from 2 to 158 with a mean of 123 for maritally satisfied women and a mean of 57 for maritally dissatisfied women. Internal consistency coefficients ranged from .63 to .87 for women, and test-retest reliability measured over a 1-month interval was .84 for women (Freeston & Plechaty, 1997).

Beck Depression Inventory (BDI)

The Beck Depression Inventory (BDI; Beck & Beamesderfer, 1974) is a widely used 21-item self-report inventory for assessing depressive symptomotology. Although BDI scores alone do not provide sufficient information to diagnose major depression, Steer, Brown, Beck, and Sanderson (2001) found that mean BDI scores of 18, 27, and 34 were associated with mild, moderate, and severe major depressive episodes, respectively.

Body Satisfaction Scale

A modified version of the Satisfaction and Dissatisfaction with Body Parts Scale (Berscheid, Walster, & Bohrnstedt, 1973) was used to measure body image. Participants rated eight body parts (e.g., buttocks, legs, thighs) on a 5-point Likert scale ranging from *extremely dissatisfied* (1) to *extremely satisfied* (5). Previous studies support the internal consistency (alpha = .94), reliability (3-week test-retest reliability = .90), and validity of the adapted questionnaire (Stice, Nemeroff, & Shaw, 1996).

Female Sexual Function Index (FSFI)

The FSFI (Rosen et al., 2000) is a 19-item self-report measure of female sexual function that provides scores on six domains of sexual function as well as a total score. The domains assessed have been confirmed using factor analyses and include: desire (2 items), arousal (4 items), lubrication (4 times), orgasm (3 items), satisfaction (3 items), and pain (3 items). The FSFI was developed on a female sample of 131 normal controls (age range, 21–68) and 128 age-matched subjects (age range, 21–69) who met *DSM-IV* criteria for Female Sexual Arousal Disorder (FSAD). The FSFI has been shown to discriminate between control women and women with FSAD (Rosen et al., 2000), and between control women and women with Female Orgasmic Disorder and Hypoactive Sexual Desire Disorder (Meston, 2003). On the basis of the full sample of FSAD and control women, internal consistency coefficients ranged from .89 to .97, and test-retest reliabilities

ranged from .79 to .88. Divergent validity has been established using the Locke–Wallace Marital Adjustment Test (Locke & Wallace, 1959).

Index of Sexual Satisfaction (ISS)

The ISS (Hudson, Harrison, & Crosscup, 1981) is a 25-item scale designed to measure the degree of satisfaction one has with the sexual aspect of his or her relationship. Internal consistency was estimated using Cronbach's alpha = .92. The known-groups validity coefficient is .76, as determined by the point biserial correlation between group status (troubled vs. untroubled criterion groups) and the ISS scores. Negatively worded items were reverse scored and all items were summed for a possible score range of 25–175.

Daily Diary

Participants indicated on a daily basis the number of times they had engaged in the following three activities: masturbation, affectionate intimate contact with partner (i.e., deep kissing or caressing genital areas), and sexual intercourse. For each activity they had engaged in, they rated the activity on a scale of 1 (*unsatisfactory or even unpleasant*) to 4 (very satisfactory and pleasant), indicated whether the activity was self-initiated, partner-initiated, or both, and whether or not the activity had resulted in orgasm. They also indicated how often they had experienced sexual thoughts that day (1 = *not at all* to 9 = *sexual thoughts frequently*) and, if they had reported sexual thoughts, whether sexual excitement accompanied the thoughts (1 = *sexual thoughts not associated with feelings of excitement* to 9 = *sexual thoughts frequently associated with feelings of sexual excitement*). The frequencies of intimate contact, masturbation, and sexual intercourse were averaged across the 4-weeks of daily diaries to provide a mean number of each of these activities per week. The frequencies of sexual thoughts and sexual excitement with thoughts were averaged across the 4-weeks of daily diaries to provide a mean number of thoughts/excitement with thoughts per day.

Subjective Film Scale

A self-report rating scale, adapted from Heiman and Rowland (1983), was used to assess subjective measures of physical sexual arousal (6 items), mental sexual arousal (3 items), autonomic arousal (5 items), anxiety (1 item), positive affect (11 items), and negative affect (11 items) following presentation of erotic films during the two

experimental sessions. Participants rated each of these items, depending on the degree to which they experienced the sensations, on a 7-point Likert scale, from 1 (*not at all*) to 7 (*intensely*). The following six items on the scale defined subjective physical sexual arousal: warmth in genitals, genital wetness or lubrication, genital pulsing or throbbing, breast sensation, genital tenseness or tightness, and any genital feelings. The following three items comprised mental sexual arousal: sexually aroused, sexual desire, and mental sexual arousal.

Physiological Measures

A vaginal photoplethysmograph (Sintchak & Geer, 1975) was used to measure VPA responses. VPA was sampled at a rate of 60 samples/s throughout the entire 180 s of neutral film and 300 s of erotic film, band-pass filtered (0.5–30 Hz), and recorded on a Dell Pentium computer using the software program AcqKnowledge III, Version 3.2 (BIOPAC Systems, Inc., Santa Barbara, CA) and a Model MP100WS data acquisition unit (BIOPAC Systems, Inc.) for analog/digital conversion. In accordance with previous studies of this nature (e.g., Meston & Heiman, 1998), artifacts caused by movement or contractions of the pelvic muscles were deleted using the computer software program following visual inspection of the data. VPA scores were computed for both the neutral and erotic films by averaging across the entire 3 min of the neutral and 5 min of the erotic film stimuli. Separate VPA difference scores were computed for each group and condition by subtracting the average VPA score during the neutral film from the average VPA score during the erotic film.

RESULTS

Baseline Sexuality Variables

Comparisons were made between groups on FSFI domain scores of sexual desire, arousal, lubrication, orgasm, satisfaction, and pain, and on the Index of Sexual Satisfaction total score (see Table I). There were no significant differences between hysterectomy and fibroid groups on measures of sexual satisfaction or on any of the FSFI domains. Both groups scored within the normal range on the FSFI domains of Desire, Arousal, Orgasm, and Satisfaction.

The means and *SEM*s by group for the daily diary ratings averaged across the 4-week period are presented in Table II. A 2 (Group: hysterectomy vs. fibroid) × 5 (Activity: intimate contact, masturbation, sexual intercourse,

Table II. Daily Diary Frequency Ratings by Group

Sexual activity	Hysterectomy		Fibroid	
	M	*SEM*	*M*	*SEM*
Intimate contact	1.1	.29	1.7	.42
Masturbation	0.9	.37	0.8	.22
Sexual intercourse	2.0	.32	1.2	.23
Sexual thoughts	3.5	.34	3.6	.38
Sexual excitement associated with sexual thoughts	3.4	.39	3.2	.45

Note. Means for intimate contact, masturbation, and sexual intercourse items are based on the average number of activities recorded per week, averaged across the 4-week period. Means for sexual thoughts and sexual excitement associated with sexual thoughts are based on an item response format of *not at all* (1) to *frequently* (9), and refer to the average number of thoughts/excitement with thoughts per day, averaged across the 4-week period.

sexual thoughts, excitement with thoughts) repeated-measures MANOVA was conducted on daily diary ratings to examine whether group differences existed on any of these measures. The main effect for group was not significant and the interaction between group and activity was not significant (*p* values all >.3).

Frequency ratings were calculated for the intercourse satisfaction ratings, the number of partner-initiated intercourse encounters, and the frequency of intercourse encounters resulting in orgasm. Overall, the women in the fibroid group rated 81% of all sexual intercourse encounters as being either "quite" or "very" satisfactory and pleasant, 12% as being "neither satisfactory nor unsatisfactory," and 7% as being "unsatisfactory or unpleasant." Women who had undergone hysterectomy rated 89% of sexual intercourse encounters as being "quite" or "very" satisfactory, and 11% as being "neither satisfactory nor unsatisfactory." There were no reports of sexual intercourse being unsatisfactory or unpleasant among these women. These group differences in intercourse satisfaction ratings were not significant (*p* > .20). Approximately 48% of sexual intercourse encounters were solely partner-initiated among women in the fibroid group compared with approximately 33% among women in the hysterectomy group. Sexual intercourse encounters resulted in orgasm for approximately 81% of women in the fibroid and 76% of women in the hysterectomy groups, respectively.

Sexual Arousal

Physiological Measures

Table III shows the means and *SEM*s for VPA scores as a function of group, condition, and film type. To

Table III. Vaginal Pulse Amplitude Responses to Neutral and Erotic Films

| | Hysterectomy | | | | Fibroid | | | |
| | Neutral | | Erotic | | Neutral | | Erotic | |
	M	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
No-exercise condition	$1.76^{a,b}$	0.11	$2.06^{a,b}$	0.08	$3.75^{a,b}$	0.72	$4.94^{a,b}$	1.09
Exercise condition	2.50^{a}	0.26	4.15^{a}	0.67	2.91^{a}	0.41	4.84^{a}	1.04

[a]Significant difference between films, within group, and condition ($p < .05$).
[b]Significant difference between groups, within film, and condition ($p < .05$).

examine whether the erotic films were effective in eliciting physiological sexual arousal, a 2 (Group: hysterectomy vs. fibroid) $\times$ 2 (Condition: exercise vs. no-exercise) $\times$ 2 (Film: neutral vs. erotic) ANOVA was conducted on average VPA scores. Results yielded a significant main effect for Group, $F(1, 30) = 4.65, p < .05$, for Film, $F(1, 30) = 26.79, p < .001$, and a significant Condition $\times$ Film interaction, $F(1, 30) = 4.03, p = .05$. The main effect for group indicated the fibroid group showed higher VPA responses to the neutral and erotic films compared with the hysterectomy group. The main effect for Film indicated the erotic stimuli elicited physiological sexual arousal among women in this study. Post hoc analyses revealed significantly higher levels of VPA responses to the erotic versus neutral films during both the exercise, $t(31) = 4.13, p < .001$, and no-exercise, $t(31) = 3.04, p < .01$, conditions. There were no significant differences in VPA responses between exercise and no-exercise conditions during either the neutral or erotic film presentations ($p > .05$).

To examine the effects of exercise on physiological sexual arousal, a 2 (Group) $\times$ 2 (Condition) ANOVA was conducted on VPA difference scores (calculated as the difference in VPA between neutral and erotic films). Results indicated a significant main effect for exercise, $F(1, 30) = 4.03, p = .05$, such that VPA difference scores were significantly higher during the exercise versus no-exercise condition (see Fig. 1 for means and *SEM*s). The main effect for Group was not significant, $F(1, 30) = 1.46, p = .24$, and the interaction between Group and Condition was not significant, $F(1, 30) < 1$.

Exploratory analyses were conducted to examine whether an association existed between length of time posthysterectomy and VPA responses, and whether VPA responses differed between women in the hysterectomy group who had an abdominal versus vaginal surgical procedure. There were no significant correlations between time posthysterectomy and VPA difference scores during either the exercise or no-exercise conditions (p values all > 0.3), and no significant differences in VPA difference

scores by surgery type in either the exercise or no-exercise conditions (p values all > 0.4).

Subjective Measures

The means and *SEM*s for the six subjective measures (physical sexual arousal, mental sexual arousal, autonomic arousal, anxiety, positive affect, negative affect) by condition are presented in Table IV. A 2 (Group) $\times$ 2 (Condition) $\times$ 6 (Subjective Measure) repeated-measures MANOVA was conducted on self-report ratings to the erotic films. The results indicated a significant main effect for Measure, $F(5, 25) = 21.19, p < .001$, and a significant Measure $\times$ Condition interaction, $F(5, 25) = 3.16, p < .05$. Follow-up tests showed significantly lower levels of negative affect, $t(30) = 2.80, p < .01$, and higher levels of
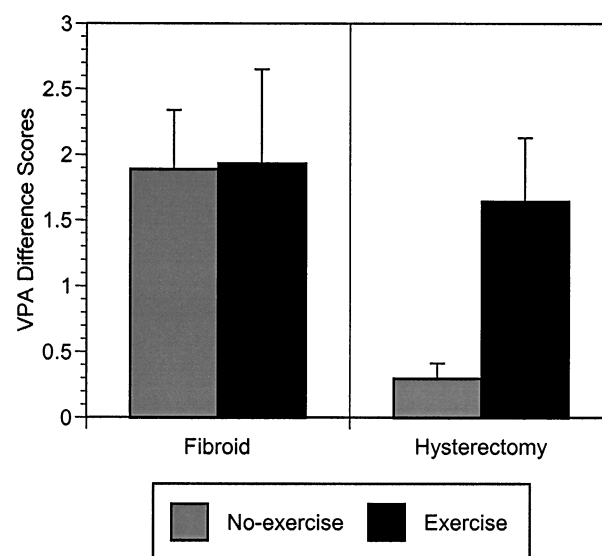

Fig. 1. Mean ($\pm$ *SEM*) vaginal pulse amplitude difference scores (calculated as the VPA response to the erotic film minus the VPA response to the neutral film) during the exercise and no-exercise conditions.

Table IV. Subjective Ratings to Erotic Films

	Hysterectomy				Fibroid				Combined			
	No-exercise		Exercise		No-exercise		Exercise		No-exercise		Exercise	
	M	SEM	M	SEM	M	SEM	M	SEM	M	SEM	M	SEM
Mental sexual arousal	4.4	.38	4.5	.37	3.9	.45	4.1	.44	4.1	.30	4.3	.29
Physical sexual arousal	4.1	.43	4.1	.36	3.6	.41	3.6	.36	3.9	.29	3.8	.26
Positive affect	3.7	.31	3.9	.23	3.3	.40	3.7	.43	3.5	.26	3.8	.26
Negative affect	1.4	.07	1.3	.04	1.6	.08	1.4	.06	1.5[a]	.06	1.4[a]	.04
Anxiety	1.4	.17	1.1	.10	1.7	.29	1.2	.18	1.6	.18	1.2	.11
Autonomic arousal	3.3	.34	3.7	.36	2.7	.27	3.4	.36	3.0[a]	.22	3.5[a]	.26

Note. Absolute range, 1–7.

[a]Significant difference between conditions ($p < .05$).

self-reported autonomic arousal, $t(30) = 2.37, p < .05$, to the erotic films during the exercise versus no-exercise condition. There was also a trend toward higher levels of positive affect, $t(30) = 1.74, p = .09$, and lower levels of anxiety, $t(30) = 1.83, p = .08$, during the exercise versus no-exercise condition.

Separate Pearson correlations were conducted between subjective mental sexual arousal, subjective physical sexual arousal, and VPA difference scores during the exercise and no-exercise conditions, by Group. There were no significant correlations at $p < .05$. Correlations and corresponding p-values are presented in Table V.

DISCUSSION

This study examined the effects of autonomic activation on sexual arousal responses in women with a history of uterine fibroids who had and had not undergone hysterectomy. The uterine supporting ligaments contain sympathetic, parasympathetic, sensory, and sensory–motor nerve types and are considered a major pathway for autonomic nerves to the pelvic organs. Based on research that indicates these ligaments are transected in both radical and simple hysterectomy (Butler-Manuel, Buttery, A'Hern, Polak, & Desmond, 2002), and on research indicating autonomic innervation is important for physiological sexual arousal (Giuliano et al., 2002), it was hypothesized that women who have undergone hysterectomy would have an impaired vasocongestive response to erotic stimuli, and that this would be most apparent under conditions of heightened autonomic arousal.

Inconsistent with the hypothesis that physiological sexual arousal is impaired with hysterectomy surgery as a result of severed autonomic input, exercise significantly increased VPA responses in women who had undergone hysterectomy. This finding is consistent with those previously reported in nonhysterectomized, sexually functional women (Meston & Gorzalka, 1995, 1996a, 1996b). Given that exercise causes changes in a number of central and peripheral systems this does not, however, definitively indicate that autonomic pathways remain intact with hysterectomy surgery. At the intensity used in this study, exercise significantly increases sympathetic nervous system activity (Mazzeo & Marshall, 1989) and parasympathetic nervous system activity is substantially increased postexercise. However, epinephrine and/or norepinephrine released from the adrenal medulla during exercise could

Table V. Correlations Between VPA Difference Scores and Subjective Ratings of Mental Sexual Arousal and Physical Sexual Arousal by Condition

	Hysterectomy				Fibroid			
	No-exercise		Exercise		No-exercise		Exercise	
	r	p	r	p	r	p	r	p
Subjective mental sexual arousal	.06	.84	.04	.91	−.37	.14	.12	.66
Subjective physical sexual arousal	.17	.57	.39	.17	−.31	.23	−.07	.78

Note. VPA differences scores are calculated as the VPA response to the erotic film minus the VPA response to the neutral film.

have also feasibly facilitated physiological arousal, as could have exercise-induced changes in endocrine factors, neuromediators, or substances released by endothelial cells (Giuliano et al., 2002).

The finding that women who had undergone hysterectomy showed lower VPA responses during the no-exercise condition than women with uterine fibroids contrasts with prior research of this nature. In the one previous study that has examined physiological sexual responses in women who have undergone hysterectomy, Bellerose and Binik (1993) found no significant differences in VPA responses between women who had undergone hysterectomy and a group of nonsurgical control women. One explanation for the discrepancy is that there were differences between studies in control groups. This study used women with a history of uterine fibroids as the control group, whereas Bellerose and Binik used a nonsurgical control group. Although the authors did not screen for absence of uterine fibroids, it is unlikely the women in Bellerose and Binik's study had as extensive a history of fibroids as those women in this study. Women with uterine fibroids have more blood flow to the uterus simply because the uterus is larger with the fibroids attached and therefore demands more blood. Although it is unclear whether this would also impact resting blood flow to other genital areas, it is feasible that, in this study, levels of VPA were higher among women with fibroids for this reason alone. This explanation might also help to understand why, in contrast to prior studies on exercise and sexual arousal in nonhysterectomized women (Meston & Gorzalka, 1995, 1996a, 1996b), women in the fibroid group did not show an increase in VPA with exercise. Possibly, the high levels of blood engorgement in genital tissue during baseline rendered further increases in engorgement with sexual arousal and/or exercise impossible.

An alternative explanation for the discrepant findings between control women in this and Bellerose and Binik's (1993) study is that due to random sampling differences between groups of hysterectomized women, the women in Bellerose and Binik's study may have had more intact sexual arousal processes than did those in this study. This would be consistent with Bellerose and Binik's finding that the women who volunteered to take part in the second (psychophysiological) session of the study ($n = 58$) reported significantly higher levels of sexual arousal than did those women who participated in the first session only ($n = 129$).

Although speculative, a third interpretation of the finding that women in the hysterectomy group showed lower VPA responses during the no-exercise condition than did women in the fibroid group warrants mention. It is possible that hysterectomy did, in fact, sever autonomic

fibers required for physiological sexual responding but, under conditions of intense autonomic activation (i.e., exercise), the existing fibers helped compensate for those damaged with surgery and allowed for a substantial vaginal response to erotic stimulation. As noted earlier, between subject comparisons in VPA measures need to be interpreted with caution given the wide variability in VPA baseline responses between women and the inability to calibrate VPA responses.

The higher levels of VPA responses to erotic stimuli during the exercise versus no-exercise condition were not accompanied by substantially higher reports of mental or physical sexual arousal, and correlations between subjective and physiological measures of sexual arousal were not significant. Numerous studies of this nature have noted a desynchrony between subjective and physiological measures of sexual arousal in women (for review, see Meston, 2000). One explanation for this desynchrony is the contrived nature of the laboratory setting used in this type of research, which may limit the extent to which a woman can "feel" sexually aroused. Or, it may be the case that women estimate their degree of sexual arousal using standards other than genital cues. For women, external stimulus information such as relationship satisfaction, mood state, and sexual scenarios may play a more important role in assessing feelings of sexual arousal than do internal physiological cues. The significantly lower levels of negative affect and a trend towards higher positive affect and lower anxiety to the erotic films during the exercise versus no-exercise condition deserves mention. Feasibly, this elevated mood state following exercise could account for the higher levels of physiological sexual arousal also noted with exercise. If this were the case, however, one would also expect to have seen significantly higher subjective reports of sexual arousal during the exercise versus no exercise condition.

Women who had and had not undergone hysterectomy did not differ significantly on validated measures of sexual desire, arousal, orgasm or sexual satisfaction, and did not differ significantly in the frequency of weekly intimate contact, masturbation, or sexual intercourse. According to the FSFI scores, women in the fibroid group reported higher than normal levels of sexual pain or discomfort with vaginal penetration and, according to the daily diary ratings, reported more sexual encounters as being unsatisfactory or unpleasant, and self-initiated a lower percentage of sexual intercourse encounters than did women in the hysterectomy group. These findings are likely explained by the fact that women in the fibroid group all had a current diagnosis of benign uterine fibroids—a condition commonly associated with sexual pain. According to the FSFI scores, women who had undergone hysterectomy

reported below normal levels of vaginal lubrication with sexual activity. This finding is consistent with the low levels of VPA responses to erotic films also noted among hysterectomy women in the no-exercise condition. Genital vasocongestion and lubrication are integrally related in women; engorgement of the genital vascular network increases pressure inside the vaginal capillaries, which results in lubrication of the epithelial surface of the vaginal wall (Levin, 1992).

A number of factors limit the generalizability of the present findings. Although efforts were made to recruit a homogeneous sample of women (e.g., history of benign uterine fibroids, at least one intact ovary, premenopausal, no medications, minimum 1 year posthysterectomy, active sexual relationship), differences between hysterectomy women were apparent on a number of factors that may be important to consider in studies of this nature. Most notably, there was a wide range in the time period posthysterectomy (13 months–10 years), and the type of hysterectomy surgery varied within the group (7 abdominal; 7 vaginal). Studies have suggested that hysterectomy with or without oophorectomy can bring about menopause and this no doubt can impact sexual function (e.g., Virtanen, Makinen, Tenho, Kiiholma, & Hirovnen, 1993). Although menopause is more likely to occur the greater the time lag posthysterectomy, this was controlled for in this study as peri- and postmenopausal women were excluded from participation based on hormonal assay results. There were no significant correlations between time posthysterectomy and VPA responses; however, the small sample size rendered it impossible to effectively examine these relations.

With regard to whether different surgical procedures affect sexual outcomes, comparable to the findings noted here, one recent study found no differences in sexual outcomes between abdominal or vaginal hysterectomy approaches (Gutl, Greimel, Roth, & Winter, 2002). More comprehensive studies of multiple hysterectomy types have also failed to find significant differences in sexual outcomes based on surgical approach (e.g., Carlson et al., 1994; Ferroni & Deeble, 1996; Rhodes et al., 1999). The measures of sexual function used in these studies, however, were notably limited, and the sample size used in this study was too small to draw conclusions regarding surgery type and sexual outcomes.

To summarize, the findings from this study suggest potential impairment of physiological sexual arousal with hysterectomy surgery. The hypothesis that this impairment is due to severed autonomic input was not supported. These conclusions are based on comparisons between women who have undergone surgery for benign uterine fibroids and women who currently are diagnosed with benign uterine fibroids. Whether women with benign fibroids differ in their sexual arousal responses to increased autonomic activation from women without fibroids is worthy of further investigation.

ACKNOWLEDGMENTS

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