SEXUAL MEDICINE REVIEWS REVIEW

The Effects of Exercise on Sexual Function in Women

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ABSTRACT

Background: Acute exercise is associated with transient changes in metabolic rate, muscle activation, and blood flow, whereas chronic exercise facilitates long-lasting adaptations that ultimately improve physical performance. Exercise in general is known to improve both physical and psychological health, but the differential effects of brief bouts of exercise vs long-term exercise regimens on sexual function are less clear.

Aim: The purpose of this review was to assess the direct and indirect effects of both acute and chronic exercise on multiple domains of sexual function in women.

Methods: A literature review of published studies on exercise and sexual function was conducted. Terms including "acute exercise," "chronic exercise," "sexual function," "sexual arousal," "sexual desire," "lubrication," "sexual pain," and "sexual satisfaction" were used.

Outcomes: This review identifies key relationships between form of exercise (ie, chronic or acute) and domain of sexual function.

Results: Improvements in physiological sexual arousal following acute exercise appear to be driven by increases in sympathetic nervous system activity and endocrine factors. Chronic exercise likely enhances sexual satisfaction indirectly by preserving autonomic flexibility, which benefits cardiovascular health and mood. Positive body image due to chronic exercise also increases sexual well-being. Though few studies have examined the efficacy of month-long exercise programs for the treatment of sexual dysfunction, exercise interventions have alleviated sexual concerns in 2 specific clinical populations: women with anti-depressant-induced sexual dysfunction and women who have undergone hysterectomies.

Conclusions: This review highlights the positive effects of acute and chronic exercise on sexual function in women. Directions for future research are discussed, and clinicians are encouraged to tailor specific exercise prescriptions to meet their patients' individual needs. **Stanton AM, Handy AB, Meston CM, et al. The Effects of Exercise on Sexual Function in Women. Sex Med Rev 2018;XX:XXX−XXX.**

Key Words: Female Sexual Function; Acute Exercise; Chronic Exercise; Sexual Dysfunction

INTRODUCTION

The benefits of exercise on both physical and mental health are well documented in the scientific literature and are frequently conveyed by popular media. According to the American College of Sports Medicine, exercise and physical activity decrease the risk of developing congenital heart disease, stroke, type 2 diabetes, and some forms of cancer.[1] Exercise also contributes to the prevention and improvement of mild to moderate depressive and anxiety disorders, enhances cognitive function, and improves quality of life.[1] However, the relationship between exercise and sexual function has received significantly less attention than the effects of exercise on physical and mental health. Though the connection between sexuality and exercise is perhaps less intuitive, many of the physiological mechanisms involved in exercise are also implicated in female sexual function. If there is a significant relationship between exercise and improvements in sexual health, exercise could be a particularly appealing form of treatment for sexual concerns, as it does not carry the stigma that is often associated with sex therapy and pharmacotherapy. Individuals may avoid seeking help for a sexual concern due to discomfort, shame, or fear of not being taken seriously by their providers. Primary care providers often find it challenging to talk about sexual matters in the exam room, which could result in missed opportunities for prevention and intervention.[2,3] Given these challenges, exercise may be an attractive treatment option, either as a stand-alone intervention or as a complement to other forms of treatment.

Exercise has both an acute phase, during which homeostatic adjustments occur, and a more chronic phase, which is

Received September 12, 2017. Accepted February 12, 2018.

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https://doi.org/10.1016/j.sxmr.2018.02.004

accompanied by long-term physiological adaptations. During and immediately following a bout of exercise, there are metabolic and neuromuscular changes that are proportional to increases in metabolic rate. Oxygen consumption, an index of metabolic rate, can increase from around 3 mL oxygen/kg/min at rest to between 50 and 70 mL oxygen/kg/min, depending on an individual's average level of physical activity.[4] A few hours after exercise, oxygen consumption returns to baseline. These metabolic changes are transient. Other changes that occur in order to meet the demands of increased metabolic rate include altered blood flow to the active muscles, increased heart rate, increased breathing rate, secretion of stress hormones (eg, adrenocorticotropic hormone, cortisol, catecholamines), and increased body temperature.[5] These changes maintain the constancy of the body's internal state during exercise.[4]

When exercise is repeated regularly, chronic changes occur as early as a few weeks following the start of a new regimen.[4] The nature of these more long-term changes depends on the type of exercise. A long-distance runner, for example, will experience different neuromuscular changes following months of training than will a wrestler. The chronic effects of exercise are also influenced by an interaction of several other important factors, such as previous exposure to the activity, the type of muscle action, and duration of the activity. Individual differences in responses to the same exercise stimulus affect the speed at which long-term adaptations occur.[6] Variations in the timing and composition of food intake and the absorption of nutrients may also impact chronic adaptations. For example, eating carbohydrates or a combination of carbohydrates and protein reduces the expression of genes involved in lipid metabolism,[7] and there have been significant differences in training adaptation following dietary interventions.[8] Acting together, these factors influence the pathways that are involved in protein synthesis or degradation, leading to changes in performance.

Chronic exercise regimens typically emphasize either endurance (aerobic) training or strength (resistance) training. Endurance training improves resistance to fatigue by increasing the maximal oxygen uptake ($V0_{2max}$).[4] Increases in $V0_{2max}$ result from changes to muscle properties following training, enabling individuals to take on an increased physiological "workload" during subsequent exercise.[9] Unlike endurance training, strength training increases muscle strength, or the amount of force that is produced by a given muscle. Muscle strength improves over time when individuals use resistance bands, machine weights, or free weights to manipulate the intensity and number of repetitions as well as the length of the recovery period between repetitions.[10]

Given the differences in the effects of acute and chronic exercise, this review addresses both types of exercise in relation to female sexual function. We pay particular attention to the domains that appear to be most impacted by exercise: sexual arousal, desire, and satisfaction. Sexual arousal has both a physiological (ie, genital) and a subjective (ie, being mentally "turned on") component, both of which are associated with increased engagement (physiological or cognitive) in response to a sexual stimulus.[11] Desire is more indicative of motivation to engage in or be receptive to a sexual event, and satisfaction reflects the fulfillment of one's sexual wishes, expectations, or needs.[11] This review also highlights populations with specific types of sexual dysfunction that may benefit from exercise interventions.

THE EFFECTS OF ACUTE EXERCISE ON PHYSIOLOGICAL SEXUAL AROUSAL

Over the past 2 decades, research has demonstrated a strong link between acute exercise and increased physiological (ie, genital) sexual arousal in women. Acute exercise influences a number of bodily systems that could feasibly impact women's physiological sexual arousal. Exercise has been shown to positively affect a variety of hormones such as cortisol,[12] estrogen,[13] prolactin,[14] oxytocin,[15] and testosterone,[16,17] all of which have been linked to arousal, some more strongly than others. The effects of exercise on hormonal responses in women vary based on the type of exercise and, for pre-menopausal women, the menstrual cycle. 1 Study found that moderate- to high-intensity (60−80% $V0_{2max}$) exercise provokes increases in circulating cortisol levels, whereas low-intensity (40% $V0_{2max}$) exercise leads to a reduction in circulating cortisol levels.[12] In another study, 30 minutes of exercise at 60% $V0_{2max}$ during the luteal phase resulted in significant increases in estradiol; this was not the case during menses.[18] More recent work has demonstrated that an exercise regimen of 150 minutes of moderate to vigorous aerobic exercise over a 16-week period resulted in significant changes in estrogen metabolism.[13] Prolactin also increases post-exercise. In a small sample of women runners, prolactin concentrations increased significantly following physical activity.[19] There is also evidence for increased oxytocin following prolonged *endurance* exercise; oxytocin levels do not increase following short bursts of high-intensity exercise or steady runs on a treadmill.[15] The effects of exercise on testosterone also depend on the type of exercise. Testosterone does not tend to increase following resistance exercise,[20,21] but it is elevated after aerobic exercise in pre-menopausal women.[22]

These hormones either have direct or indirect effects on sexual arousal function in women. Hamilton and colleagues[23] found that some women experience an increase in cortisol during sexual arousal. Women who exhibited this pattern tended to have lower scores on the arousal domain of the Female Sexual Function Index. The authors of this study suggested that a laboratory test of sexual responding might be more stressful for women who have experienced arousal dysfunction. Estrogen is known to play a significant role in the regulation of female sexual arousal function. Estradiol levels influence nerve transmission and affect cells in both the peripheral and central nervous systems. Chronic decreases in serum estrogen levels result in the thinning of the vaginal epithelium and the atrophy of vaginal wall smooth muscle, which lead to a decrease in vasodilation and ultimately to decreased genital sensations.[24] The relationship between prolactin and arousal is more indirect than that of estrogen and arousal. There are pronounced increases in prolactin levels following masturbation-induced orgasm,[25] which may provide a negative feedback signal controlling sexual arousal and thus decreasing the likelihood of continued sexual activity.[26] Like prolactin, oxytocin appears to be most related to orgasm function,[27] but recent data indicate that oxytocin administration has more specific effects on the orgasmic/post-orgasmic interval as well as on parameters of partner interactions (eg, contentment after intercourse).[28] Though these effects are not specific to arousal, they may contribute to a positive feedback loop that facilities sexual arousal with a particular partner. Androgens, including testosterone and dihydrotestosterone, may facilitate increased arousal through aromatization to estrogens,[29] which are important for maintaining the health and integrity of vaginal tissue. Androgens have also been shown to influence attentional aspects of sexual function,[30] which contribute to arousal.

It is also feasible that sympathetic nervous system (SNS) activation may be driving the association between acute exercise and increased physiological sexual arousal in women. Biochemical and physiological research indicates that diffuse SNS discharge occurs during the later stages of sexual arousal in women,[31] with marked increases in heart rate and blood pressure occurring during orgasm.[32] Increases in plasma norepinephrine, a sensitive index of SNS activity, have also been shown to accompany increases in sexual arousal during intercourse.[33]

A large body of literature supports the critical role of the SNS in increasing sexual arousal following short bouts of exercise. In a series of laboratory studies,[34,35] Meston and Gorzalka examined the direct effects of acute exercise on physiological sexual arousal. The first of these studies required sexually functional participants to engage in 20 minutes of intense exercise (stationary cycling) prior to viewing a non-sexual and erotic film sequence.[34] The procedure consisted of an orientation screening, questionnaire session, and a 20-minute bicycle ergometer fitness test, followed by 2 counter-balanced experimental sessions (exercise, no exercise), which took place on different days. During the fitness test, the experimenters determined each participant's maximum volume of oxygen uptake so that they could instruct the participants to cycle at a constant 70% of their estimated maximum volume. By ensuring that all participants worked at equivalent levels of their $V0_{2max}$, differences in physiological responses resulting from variations in fitness levels were minimized. During the exercise session, participants cycled for 20 minutes and then watched a non-sexual film followed by an erotic film while their genital arousal (recorded as vaginal pulse amplitude [VPA]) was measured with a vaginal photoplethysmograph.[36] In the no-exercise condition, participants sat for 20 minutes, inserted the vaginal photoplethysmograph, and viewed a different non-sexual and erotic film sequence. The results revealed that VPA was significantly higher during the presentation of the erotic film after exercise than it was during the erotic film in the no-exercise condition. There were no significant differences between conditions in VPA responses during the non-sexual film, indicating that exercise did not simply increase blood flow to the genitals; rather, it prepared the woman's body for sexual arousal so that when she was in a sexual context (eg, viewing the erotic film) her body responded more intensely.

In a follow-up study using a similar methodology, Meston and Gorzalka[36] examined the effect of timing on the relationship between exercise and increased sexual arousal in women by measuring physiological arousal in response to erotic films at either 5, 15, or 30 minutes post-exercise. At both 15 and 30 minutes post-exercise, there was a significant increase in physiological arousal (indexed by VPA) to the erotic films compared to the no-exercise control condition. However, there was no significant increase in VPA immediately following exercise. During and immediately following exercise, a decrease in vascular resistance of the working muscles typically causes a significant increase in blood flow to those muscles.[37] Therefore, blood flow may have shifted away from the genital region to temporarily help restore the working muscles. The finding that exercise inhibited genital arousal immediately following exercise but facilitated genital arousal at 15 and 30 minutes post-exercise led the authors to speculate that there may be an optimal time for engaging in sexual activity following exercise.

To determine if there is indeed an ideal window of time post-exercise for sexual activity, Lorenz and colleagues[38] performed a secondary analysis of participants from the control conditions of 3 previously published studies.[39–41] SNS activity was assessed using heart rate variability, which refers to the degree of variability in the lengths of time between successive heartbeats. Heart rate variability is a useful non-invasive index of the relative balance of sympathetic and parasympathetic forces acting on the heart.[42] As predicted, the results revealed a curvilinear relationship between SNS activity and women's physiological sexual arousal. That is, moderate increases in SNS activity were associated with greater physiological sexual arousal responses, while low and high SNS activation were associated with lower physiological sexual arousal. These results suggested that there is an optimal level of SNS activity from acute exercise for the facilitation of genital sexual arousal in women.

If exercise increases genital arousal via SNS activation, then blocking SNS arousal during exercise should diminish the enhancing influence of exercise on VPA responses. To test this hypothesis, Meston and Gorzalka[43] administered either placebo or 0.2 mg of clonidine, which acts centrally as a norepinephrine antagonist and peripherally as an inhibitor of sympathetic outflow, to 30 sexually functional women in 2 counter-balanced sessions. Before viewing the experimental films, half of the participants engaged in 20 minutes of exercise in order to elicit significant SNS activation, and the other half did not exercise. Following heightened SNS activation (via acute exercise), there was a significant decrease in VPA responses to the erotic film in the clonidine condition compared to placebo condition. Among the participants who did not engage in exercise prior to viewing the film sequence, clonidine showed a non-significant trend toward decreasing VPA responses compared with placebo. Given that clonidine inhibited sexual responding only when participants were in a state of heightened SNS activity (ie, after acute exercise), it is likely that the drug suppressed sexual arousal by direct inhibition of sympathetic outflow. The fact that clonidine has been reported to significantly inhibit SNS, but not hormonal responses to exercise,[44] is consistent with the hypothesis that clonidine acted to inhibit sexual responding via suppressed SNS activity.

Taken together, the studies cited above demonstrate that there is a direct relationship between acute exercise and increased physiological sexual arousal in women.

THE EFFECTS OF CHRONIC EXERCISE ON SEXUAL WELL-BEING

The effects of chronic exercise on female sexual function are more challenging to assess than those of acute exercise. The only study that has directly examined the impact of a longer exercise protocol on some domain of sexual function tested the effects of a 3-week exercise regimen on both arousal and desire.[45] It is unclear if 3 weeks of exercise (in this study, the exercise program was a combination of strength and endurance training, 3 times per week) was enough to catalyze the physiological adaptations that are associated with repeated exercise. The increases in muscle size that are associated with strength training do not occur until 8−10 weeks after the start of a new regimen.[46,47] With respect to endurance training, it may take 8−12 weeks of low-level aerobic work to build a strong aerobic base.[48,49] There is also some individual variability in responsiveness to regular exercise training; for example, genetic factors play an important role in determining sub-maximal exercise rate and blood pressure.[50]

Although no studies have directly assessed the relationship between chronic exercise and sexual function in women, chronic exercise likely has a number of indirect effects on sexual well-being. There are 3 variables that are positively influenced by exercise that have also been related to different domains of sexual function: cardiovascular health, mood, and body image. The relationships between these variables and exercise, as well as subsequent connections to sexual function, are reviewed below.

Cardiovascular Health

Chronic exercise and regular physical activity are protective against cardiovascular disease.[51] Indeed, regular physical activity has been shown to reduce the risk of cardiovascular disease by one third to one half.[52] In a review of the effects of exercise training on hypertension severity, exercise not only led to a decrease in blood pressure, but also to significant reductions in plasma low density, increases in high-density lipoprotein lipid levels, and improvements in insulin sensitivity.[53] The protective effects of exercise may be due to its impact on the autonomic nervous system.[52] Altered autonomic function can have a large effect on cardiovascular disease; reduced heart rate variability, a marker of autonomic flexibility, has been associated with an increase in the incidence of coronary heart disease and mortality.[54] Correspondingly, hundreds of studies in the past several decades have demonstrated that individuals who are physically active or trained in exercise have higher heart rate variably than control groups that are comparatively sedentary. This effect appears to be consistent across age and gender. Exercise may keep the autonomic nervous system healthy by acting against age-related reductions in baroreflex function,[55] which helps maintain relatively low heart rate and decreased blood pressure.

If chronic exercise is improving cardiovascular health via vascular mechanisms, then it follows that those improvements will also be associated with enhanced sexual function. Atherosclerotic vascular disease interferes with the normal vascular physiological processes that are associated with vaginal and clitoral engorgement,[56] and hypertension is strongly linked to female sexual dysfunction. In a sample of over 400 women, 42.1% of the hypertensive women were found to have sexual problems, whereas only 19.4% of the normotensive women reported sexual concerns.[57] Medications used to treat hypertension (eg, lipid regulators, beta blockers) have also been linked to sexual dysfunction.[58] Given the positive associations between chronic exercise and cardiovascular health, developing a long-term exercise regime may be an appropriate option for controlling hypertension, enhancing vaginal blood flow, and potentially avoiding medication-induced sexual problems.

Mood

Exercise is well-known to boost mood[59] as well as decrease depression and stress.[60] Moderate-intensity exercise programs have led to improvements in affect,[61] and the anti-depressant effects of exercise tend to outlast the length of the intervention.[62] Aerobic exercise, in particular, influences mood by stimulating serotonin activity in the brain, which increases tryptophan in the blood. An enzyme found in tryptophan, 4-mono-oxygenase, facilitates the synthesis of serotonin.[63] Though most studies have examined the relationship between aerobic exercise and improved mood, there is some evidence indicating that resistance-based exercise has similar effects.[64] The mood-boosting effects of acute exercise are small and short-lived,[65] but long-lasting benefits are likely to result from chronic exercise.

The direct impact of exercise on mood may be contributing to an indirect effect of exercise on sexual satisfaction. A correlational study revealed that, among sexually active university students, 20 minutes of physical activity at least 3 times a week was associated with higher levels of sexual satisfaction.[66] Clinicians working with patients who are experiencing sexual problems should consider presenting them with this evidence, as this prescription has a high degree of clinical utility. The authors of this study suggest that the physiological benefits of exercise (eg, release of endorphins) improve mood, which then leads to an increase in satisfaction. It is also conceivable that factors other than mood, such as body esteem, may be driving the relationship between exercise and sexual satisfaction. Esteem about body parts that can be physically altered through exercise (eg, thigh size, stomach appearance, and weight) has been linked to greater sexual satisfaction, as has esteem related to body parts that cannot be easily changed through physical activity, such as the breasts and the face.[67]

Body Image

It is well known that chronic exercise improves body image. Individuals who exercise regularly have a more positive body image than those who do not, though the effect size is small.[68] Correlational research has shown that women who engage in frequent exercise have lower levels of body dissatisfaction than those who exercise less often.[69] Systematic exercise programs have also led to improved body image post-intervention compared to pre-intervention. Among women taking part in either an aerobic exercise program or a social psychology course, exercisers exhibited significant gains in body esteem over the course of the 10-week study, whereas their counterparts in the psychology course did not.[70] In general, exercise intervention studies have documented significant improvements in body image, though effects vary by type of exercise and by gender. There appears to be a greater effect of exercise on body image for those engaging in aerobic *and* anaerobic exercise (Hedges $g = 0.45$) vs one or the other; stronger effects were also linked to strenuous exercise ($g = 0.45$) compared to moderate ($g = 0.36$) or mild ($g = -0.04$) exercise. It appears as though women reap greater benefits from exercise than men ($g = 0.43$ vs $g = 0.26$).[68] According to Hausenblas and Fallon,[68] these results are due in part to: (1) increased activity levels, which contribute to the development of a lean and fit physique, one that resembles the aesthetic ideal put forth by society; and (2) improvements in psychological health, both of which enhance sexual well-being.

Positive body image is directly associated with greater sexual well-being.[71] Possible mechanisms driving this association include sexual objectification, hyper-attentiveness to one's body, and cognitive distraction. Sexual objectification (also known as "self-objectification") refers to valuing one's body only for its sexual usefulness to others. When a woman comes to view herself as a sexual object, she may develop a habitual practice of monitoring her body's outward appearance.[72] This practice reinforces a hyper-attentiveness to bodily changes as well as perceived physical flaws, both of which are particularly relevant to the sexual domain. By definition, sexual activity involves another person focusing attention on one's body. Cognitive distraction, or negative thoughts about one's body during sexual activity, contribute to a phenomenon known as "spectatoring"[73]; spectators become distracted by thoughts about their own sexual performance. Barlow model of sexual function[74] suggests that intense focus on one's own sexual performance distracts the individual from other pleasurable aspects (eg, orgasm, enhanced intimacy and emotional connection) of the sexual experience, ultimately decreasing sexual pleasure and satisfaction. It is reasonable to expect that women who feel more positively about their bodies likely experience less distraction during sex, which allows them to engage more fully in the sexual experience. This was the case in 1 study that assessed sexual satisfaction, body image, and cognitive distraction among college-aged women.[67] Results indicated that body image specific to sexual attractiveness, as well as appearance-based distracting thoughts, significantly predicted satisfaction. That is, the more esteem women had for their sexual body parts and the less they focused on their bodies during sex, the higher their sexual satisfaction.

Poor body image is also associated with sexual avoidance. Discomfort in intimate situations that arises from poor body image leads to decreased desire to engage in future sexual activity.[75] Indeed, in a study of over 350 undergraduate students, researchers found a significant relationship between negative body image and sexual avoidance.[76] Seal and colleagues[77] also examined the role of body image in predicting future sexual activity. In their study, body esteem was positively related to both self-reported sexual desire and desire in response to erotic material. That is, feeling good about one's body predicted greater desire, likely leading to increased engagement with sexual stimuli in the future. Notably, the link between body esteem and sexual desire was unrelated to body mass index, suggesting that actual body size is less relevant to sexual function than how one feels about her body.

EXERCISE AS A TREATMENT FOR SEXUAL DYSFUNCTION

Few studies have examined acute or chronic exercise protocols as stand-alone treatments for sexual dysfunction in women. There are 2 notable exceptions, and they are reviewed here. These studies developed specific exercise-based interventions to meet the needs of 2 clinical populations: women with anti-depressant-induced sexual dysfunction and women who have undergone hysterectomies.

Anti-Depressant-Induced Sexual Dysfunction

It is estimated that 1 in 6 U.S. women has been prescribed an anti-depressant,[78] primarily selective serotonin reuptake inhibitors (SSRIs) and selective norepinephrine reuptake inhibitors (SNRIs). Nearly all women taking anti-depressants (96%) report at least 1 sexual side effect,[79] most commonly difficulties with desire, arousal, or orgasm. Though both SSRIs and SNRIs are associated with these sexual side effects, SNRIs appear to impair arousal and orgasm at lower rates compared to SSRIs.[80] The sexual side effects of SSRIs are most likely linked to peripheral nervous system adrenergic pathways,[81] particularly to changes in SNS activity.[80] It is thought that SSRIs suppress SNS activity through norepinephrine release[82] as well as through sympathetic muscle and vascular nerve firing.[83] SNRIs may counter the inhibition of norepinephrine, which occurs alongside increases in serotonin, by directly increasing the availability of norepinephrine.[84] Given that moderate SNS activity, as opposed to very high or very low SNS activity, is associated with increased genital arousal, it follows that SNRIs, which suppress SNS activity less so than SSRIs, are associated with lower rates of genital arousal problems than are SSRIs.

1 Study[45] examined potential differences between the acute and chronic effects of SNS activation on sexual function in women with anti-depressant-induced sexual problems. Participants were entered into a 9-week randomized cross-over trial. Baseline levels of sexual activity were recorded for the first 3 weeks. Then, women were randomized to either 3 weeks of exercise immediately prior to sexual activity, or 3 weeks of exercise at a time unrelated to sexual activity. The exercise protocol involved 30 minutes of strength training and cardio with resistance bands, 3 times a week. To standardize the protocol, participants were instructed to maintain 70–85% of their maximum heart rate by changing resistance during exercise. At the end of 3 weeks, the women crossed over to the other exercise condition.

Results from this study indicated that, overall, exercise improved sexual desire and sexual function. There was also evidence to suggest that exercising immediately prior to sexual activity may be more beneficial than exercising in general. In aggregate, these results revealed that exercise improves sexual function in women with sexual problems due to anti-depressant medication use, and exercising immediately prior to sexual activity may provide additional benefit.

Sexual Dysfunction Following Hysterectomy

Hysterectomy is the most common form of gynecological surgery. In the United States, 80% of hysterectomies are intended to treat benign conditions.[85] Reports of beneficial outcomes of hysterectomies include the cessation of abnormal uterine bleeding, relief from menstrual symptoms and pelvic pain, and decreases in depression and anxiety.[86] However, a number of women report negative symptoms post-hysterectomy, including depression, fatigue, urinary incontinence, constipation, early ovarian failure, and sexual dysfunction.[87] With regard to sexual dysfunction, up to 40% of women report a decrease in sexual activity following the surgery,[88] as well as a lack of vaginal lubrication, loss of libido, and sexual pain. The uterine supporting ligaments contain sympathetic, parasympathetic, sensory, and sensory-motor nerve types, and they are considered a major pathway for autonomic nerves to the pelvic organs. It is feasible that the negative sexual outcomes following the procedure are a result of damage to the pelvic autonomic nerves, which may be affected by the excision of the cervix and the separation of the uterus from the cardinal and uterosacral ligaments.[89]

Given the possibility that hysterectomies may adversely affect the autonomic nerves that facilitate arousal, 1 study tested the effects of acute exercise on physiological sexual arousal in women with a history of benign uterine fibroids who had and had not undergone the procedure.[90] It was expected that women who had the procedure would have impaired physiological sexual arousal in response to erotic stimuli, and that this impairment would be most apparent after exercise. Surprisingly, exercise significantly increased VPA responses in women who had undergone hysterectomy. This effect may have been due to the release of 2 specific hormones, epinephrine and/or norepinephrine, during exercise, both of which could have facilitated physiological sexual arousal. Exercise could also have induced changes in other endocrine factors, neuromediators, or substances released by endothelial cells.[91] As such, exercise may serve as a non-invasive means of enhancing sexual responding in women who experience sexual arousal difficulties post-hysterectomy.

CONCLUSION

This review identified several domains of sexual function that are improved by either acute or chronic exercise. Acute exercise increases physiological sexual arousal in women, and the most likely mechanism associated with this relationship is SNS activation, although the roles of hormonal and other potential changes that occur with exercise cannot yet be ruled out. There appears to be an optimal level of SNS activation for the enhancement of genital arousal in women; moderate increases in SNS activity have been associated with high physiological sexual arousal responses, whereas both very low and very high SNS activation are associated with lower responses. There are a number of indirect effects of chronic exercise on sexual well-being, such as benefits in cardiovascular health, mood, and body image. Exercise-based improvements in self-esteem and body satisfaction have been noted among adolescents[92] and adults.[93,94] Exercise has also been linked to increased energy and decreased fatigue,[95] which play a positive role in women's sexuality.

Although few studies have tested exercise protocols on women who meet clinical criteria for sexual dysfunction, there are some notable exceptions. In a series of studies, Meston and Lorenz[45,90,96] examined the effects of acute exercise on sexual desire and physiological sexual arousal in women with anti-depressant-induced sexual dysfunction and women who have undergone hysterectomies. Results indicate that exercise is an effective treatment for these populations. Given the paucity of studies that have tested exercise as an intervention for sexual dysfunction, there are many variables that have yet to be examined. These variables include type of strength training (eg, number of sets and repetitions), type of cardiovascular training (eg, cycling, walking, running, swimming), and participant age (eg, pre-menopausal vs post-menopausal). Researchers might also investigate the relationship between time spent training and positive sexual health outcomes to determine the length of time required for maximum benefit. Yet another variable that could be manipulated in future exercise protocols is nutrition. Variations in the timing and composition of food intake, as well as in the absorption of nutrients, may also impact chronic adaptations to exercise. To our knowledge, no studies have examined the relationship among exercise, food intake, and sexual function; this may be an important area for future research.

3 Domains of sexual function were addressed in this review. Studies that examined the relationship between either acute or chronic exercise and some aspect of sexual function typically focused on arousal, desire, or satisfaction, ignoring other potentially relevant domains, such as orgasm, sexual pain, and lubrication. There are anecdotal reports of exercise-induced orgasm, with 1 study suggesting that these orgasms are more common among women who endorse high levels of self-consciousness during exercise,[97] but the impact of exercise (either acute or chronic) on orgasm has not been thoroughly addressed. Likewise, the relationship between exercise and sexual pain has yet to be established. There is some evidence that a program of chronic exercise decreases pain in bodily regions close to but distinct from the genitals (eg, the lower back[98]), but there has been little attention paid to the potential mitigating effects of exercise on different types of genital pain.

This review also highlights a need for more exercise intervention studies that target populations with specific types of sexual dysfunction (eg, female sexual interest/arousal disorder, female orgasmic disorder, genito-pelvic pain/penetration disorder). Researchers may also consider assessing the efficacy of combination therapies that aim to increase both physiological arousal and some other domain of sexual function. Developing and testing exercise interventions for clinical populations will enable clinicians to offer their patients exercise prescriptions for their individual sexual concerns.

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Conflict of Interest: The authors report no conflicts of interest.

Funding: None.

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