

## Anatomy and Neurophysiology of Sexual Function

Article Details	Relevant Anatomic Structures and Background Information	Neuronal Innervation	Process of Sexual Function	Process of Sexual Dysfunction and Complications
<p><b>Title:</b> Neurogenic Bladder, Neurogenic Bowel, and Sexual Dysfunction in People with Spinal Cord Injury<sup>1</sup></p> <p><b>Year:</b> 2002</p> <p><b>Authors:</b> Barbara T Benevento, Marca L Sipski</p> <p><b>Article Type:</b> Narrative Review</p>	<p>Sexual Response<sup>1</sup>:</p> <ul style="list-style-type: none"> <li>- Depends on degree of injury, location of injury, sex, and intended sexual response</li> <li>- Framework to study human sexual response: arousal, plateau, orgasm, resolution.</li> </ul>	<p>Spinal levels T11 – L2 are involved in sexual arousal in males and females.<sup>1</sup></p> <p>Male ejaculation is more complicated and includes sympathetic, parasympathetic, and somatic nervous system involvement.<sup>1</sup></p>	<p>Male erection (arousal phase) can occur in one of two ways.<sup>1</sup></p> <p>1. Reflexively through sacral stimulation and parasympathetic pathway 2. Psychogenically under control of hypogastric plexus in T11-L2 and sacral segments<sup>1</sup></p>	<ul style="list-style-type: none"> <li>- Men with complete UMN injuries above T11 can have reflex erections but will not have psychogenic erections<sup>1</sup></li> <li>- Men with incomplete UMN injuries above T11 can have reflex erections and may have psychogenic erections (depends on amount of preservation in T11-L2)<sup>1</sup></li> <li>- Men with LMN injury will not experience reflex erections but may experience psychogenic erection ((depends on amount of preservation in T11-L2)<sup>1</sup></li> <li>- With SCI any pathway involved in ejaculation can be disrupted which can lead to retrograde ejaculation (semen forced into bladder instead of out urethra).<sup>1</sup></li> <li>- Varying estimates for male SCI patients who experience ejaculation (influenced by completeness and level of injury) but there are</li> </ul>

				<p>augmentative techniques such as electroejaculation or penile vibratory stimulation that increases this rate.<sup>1</sup></p> <ul style="list-style-type: none"><li>- Orgasm has only been studied via questionnaire in male patients.<sup>1</sup></li><li>- In women, arousal consists of vaginal lubrication, clitoral swelling, increased heart rate/respiratory rate/blood pressure.<sup>1</sup></li><li>- For women with complete UMN affecting sacral segments, reflexic but not psychogenic lubrication is possible.<sup>1</sup></li><li>- Women with incomplete UMN affecting sacral segments may retain ability for reflex and psychogenic lubrication.<sup>1</sup></li><li>- Women with greater perception of light touch and pinprick sensation in T11-L2 dermatome have greater likelihood for psychogenic lubrication.<sup>1</sup></li><li>- Women with SCI are less likely to achieve orgasms if they have a complete LMN injury affecting sacral segments.<sup>1</sup></li></ul>
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				<ul style="list-style-type: none"> <li>- Some studies imply that an intact sacral reflex is needed to achieve orgasm in women and that it is a response by the autonomic nervous system.<sup>1</sup></li> </ul> <p>Sexuality<sup>1</sup>:</p> <ul style="list-style-type: none"> <li>- Libido and sexual satisfaction found to decrease in men following SCI.</li> <li>- Sexual activity often resumes within a year for men with SCI.</li> <li>- Women’s sexual desire also seems to decrease following injury.</li> <li>- Both sexes indicate a shift in preferred sexual activities after SCI to touching, kissing, hugging, and oral sex for men specifically.</li> </ul>
<p><b>Title:</b> Male Sexual Circuitry<sup>2</sup></p> <p><b>Year:</b> 2000</p> <p><b>Authors:</b> Irwin Goldstein</p> <p><b>Article Type:</b> Expert Opinion</p>	<p>A specific cluster of neurons in hindbrain is in charge of inhibition of erection. (paragigantocellular nucleus aka PGN)<sup>2</sup></p> <p>PGN sends most axons to erection neurons in lower spinal cord where they release serotonin (inhibits erection).<sup>2</sup></p>	<p>“Erection-generating center” is located in sacral segments (T12-S3).<sup>2</sup></p> <p>Sensory signals are sent via pudendal nerve to erection center. This stimulates parasympathetic neurons which send erection signals from sacral spine to penile blood vessels.<sup>2</sup></p>	<p>During arousal, excitatory signals can originate from the brain due to arousal via senses.<sup>2</sup></p> <p>Excitatory nerves in penis respond by releasing nitric oxide and acetylcholine. These signal for the penis arteries to relax, which increases blood flow. This compresses veins in the penis and keeps blood</p>	<p>Any disturbance to network of nerve pathways that connects penis to central nervous system can lead to erection problems.<sup>2</sup></p>

	<p><b>Hypothalamus<sup>2</sup>:</b> link nervous system to endocrine system and is involved in basic behaviors. Medial preoptic area (MPOA) in hypothalamus has role in sexual function suspected as recognition and organization of arousing stimuli. Also contains paraventricular nucleus which is also a processing center and releases oxytocin during sexual arousal.</p> <p>Higher brain centers are also involved in sexual response. Memory and learning have been found to influence erections.<sup>2</sup></p>		<p>within the penis causing an erection.<sup>2</sup></p> <p>After ejaculation, the sympathetic nervous system limits blood flow to the penis, causing it to be flaccid.<sup>2</sup></p> <p>Reflex erections are created from solely spinal cord input. Similar to other reflexes, physical stimulation of the penis can set off a spinal erection reflex.<sup>2</sup></p>	
<p><b>Title:</b> The Male Orgasm: Pelvic Contractions Measured by Anal Probe<sup>3</sup></p> <p><b>Year:</b> 1980</p> <p><b>Authors:</b> Joseph G. Bohlen, James P. Held, Margaret Olwen Sanderson</p>	<p><b>Male Orgasm:</b> series of regular and in some, irregular anal contractions<sup>3</sup></p>	<p>Not applicable.</p>	<p>Anal contractions during orgasm are different than anal tension during masturbation and post-orgasmic relaxation.<sup>3</sup></p> <p>Contractions during masturbation are irregular in amplitude, shape, and timing.<sup>3</sup></p> <p>At onset of orgasm, regular consecutive contractions begin with similar amplitude and waveforms (usually about 10 – 20).<sup>3</sup></p>	<p>Not applicable.</p>

<p><b>Article Type:</b> Observational Study</p>			<p>Contractions during orgasm are abrupt at onset and termination.<sup>3</sup></p>	
<p><b>Title:</b> The Female Orgasm: Pelvic Contractions<sup>4</sup></p> <p><b>Year:</b> 1982</p> <p><b>Authors:</b> Joseph G. Bohlen, James P. Held, Margaret Olwen Sanderson, Andrew Ahlgren</p> <p><b>Article Type:</b> Observational Study</p>	<p>Not applicable.</p>	<p>Not applicable.</p>	<p>Association between pelvic contractions and female orgasm.<sup>4</sup></p> <p>Female orgasm involves rhythmic pelvic contractions that are different than steady tension during relaxation and stimulation.<sup>4</sup></p> <p>Contractions during female orgasm occurs abruptly and terminates abruptly with about 7 – 13 contractions in 5 – 14 seconds.<sup>4</sup></p> <p>Synchronized contractions from anus and vagina occur, but baseline pressure levels in the anus are higher and shows greater variation.<sup>4</sup></p> <p>Duration of orgasm varies and can range from 7.4 to 107.6 seconds.<sup>4</sup></p>	<p>Not applicable.</p>
<p><b>Title:</b> Neural Control and Physiology of Sexual Function: Effect of Spinal Cord Injury<sup>5</sup></p> <p><b>Year:</b> 2017</p>	<p><b>Male Reproductive System<sup>5</sup>:</b></p> <p>Internal and external organs that work to produce, support, transport, and deliver viable sperm for</p>	<p>Male testes are innervated by T10-L1.<sup>5</sup></p> <p>Scrotal skin innervated by somatic branches of L1-L2 and S2-S3.<sup>5</sup></p>	<p><b>Male<sup>5</sup>:</b></p> <p>Ejaculation accompanied by pelvic floor contractions and sexual sensation of orgasm</p> <p><b>Female<sup>5</sup>:</b></p> <p>During arousal, vasocongestion of pelvic organs leads to vaginal</p>	<p>Typically, male ejaculation occurs in antegrade fashion but can be expelled backwards into the bladder (retrograde ejaculation) if the internal sphincter does not close completely.<sup>5</sup></p>

<p><b>Authors:</b> Andrei Krassiokov, Stacy Elliot</p> <p><b>Article Type:</b> Narrative Review</p>	<p>reproduction via sexual intercourse.</p> <p>Internal organs: testes, ductal system, bilateral seminal vesicles</p> <p>Penis = erectile tissue (corpora cavernosa, corpora spongiosum, penile crura) and unique set of veins and arteries capable of expansion. Crura joins to form external penis at penile bulb and elongates into shaft and penile glans.</p> <p>Tunica albuginea is a stocking that surrounding the penile erectile tissue.</p> <p>Urethra runs from bladder through prostate, along corpora spongiosum, to external urethral meatus in distal glans.</p> <p>External penile structures attach to pubic bone via suspensory ligament. Testicles with scrotum are attached to spermatic cord.</p> <p><b>Female Reproductive System<sup>5</sup>:</b></p>	<p>Function of male system is dependent on coordinated hormonal control from autonomic nervous system.<sup>5</sup></p> <p>Psychogenic arousal modulated by centers in T11 – L2.<sup>5</sup></p> <p>Reflexive arousal modulated by centers in S2-S4.<sup>5</sup></p> <p>Peripheral innervation of pelvis has three efferent neurons that are coordinated in pelvic plexus: somatic, thoracolumbar sympathetic, and sacral sympathetic.<sup>5</sup></p> <p>Sexual responses modulated in minute intervals by cerebral inputs and neurotransmitter alterations.<sup>5</sup></p> <p>Motor/sensory somatic control via pudendal nerve. Important for contraction of pelvic floor muscles.<sup>5</sup></p> <p>Autonomic system via pelvic nerve (sacral parasympathetic) and hypogastric nerve (thoracolumbar</p>	<p>lubrication, vaginal elongation, and uterine elevation.</p> <p>During orgasm, pelvic floor muscles rhythmically contract.</p> <p><b>Genital arousal<sup>5</sup>:</b> Coordination of neuronal circuits that results in a vascular event</p> <p>Erectile response is controlled by parasympathetic activity in smooth muscles for contraction and sympathetic activity in smooth muscle and blood vessels for flaccidity.</p> <p>Contraction neurotransmitters: norepinephrine, endothelin, angiotensin, vasopressin</p> <p>Relaxation neurotransmitters: acetylcholine, nitric oxide, Vasoactive intestinal peptide, prostaglandins, calcitonin gene-related peptide</p> <p>Parasympathetic nervous system (S2-S4) is crucial in males and females for erection.</p> <p>Nitric oxide (NO) is primary neurotransmitter for penile erection and clitoral</p>	<p>If S2-S4 is damaged following sacral SCI, T11-L2 center becomes dominant pathway for psychogenic erection.<sup>5</sup> In men, these erections are often poorer in quality because it is likely from inhibition of tonic tone or relaxation of penile cavities as opposed to actual dilation.<sup>5</sup></p> <p>Complete SCI above T10, impulses cannot reach psychogenic arousal centers in T11-L2 and cannot ascend to spinal cord for sensory perception, so reflexogenic arousal dominates.<sup>5</sup> Preservation of sacral parasympathetic neurons are important in reflex erection.<sup>5</sup></p> <p>The more cranial the complete SCI is above T11-L2, the more sensitive the reflexogenic response is due to sacral reflexes free of descending control.<sup>5</sup></p> <p>In males with SCI above T6, penile vibratory stimulation can assist with ejaculation.<sup>5</sup> This approach is not effective in those with lesions in lumbar segments.<sup>5</sup></p> <p>Genitally induced orgasms require intact sacral reflex but can achieve orgasm via stimulation outside of genitalia region or with psychogenic fantasy alone.<sup>5</sup></p>
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	<p>Internal and external organs that provide sexual arousal, orgasm, and ability for vaginal penetration.</p> <p>External genitalia (vulva) include the mons pubis, labia majora, labia minora, vaginal opening (introitus), urethral opening, clitoris, and perineum.</p> <p>Females have vascular erectile tissue (clitoris) that is filled with blood during arousal.</p> <p>Clitoris is composed of external glans, glans hood, and 2 crura that attach to ischial rami bilaterally.</p> <p><b>Kinds of Arousal<sup>5</sup>:</b>          Psychogenic: triggered by sexual thoughts generated from the 5 senses or by sexual fantasy</p> <p>Reflexogenic: produced via tactile stimulation to genitals which sends afferent stimuli to spinal cord that goes through ascending tract and activates autonomic nuclei in S2-S4 (cavernosal nerve</p>	<p>sympathetic).<sup>5</sup> Sympathetic nervous system innervates heart, blood vessels, respiratory tract, sweat glands, sexual organs, bowel, and bladder (T1-L2).<sup>5</sup> Parasympathetic neurons originate in brainstem (cranial nerves III, VII, IX, X) and in sacral spinal cord (S2-S4). S2-S4 parasympathetics innervate bladder, reproductive organs, and lower portion of gut.<sup>5</sup></p> <p>Sexual organs receive sympathetic innervation via hypogastric nerve and parasympathetic innervation via pelvic nerve.<sup>5</sup></p> <p>Afferent pathway involves innervation of genitalia via hypogastric, pelvic, and vagus nerves.<sup>5</sup> Responsible for mechanosensitivity, thermosensitivity, chemosensitivity which contribute to experience of genital stimulation.<sup>5</sup></p> <p>Psychogenic erection/vaginal lubrication mediated by sympathetic and parasympathetic, whereas reflex</p>	<p>enlargement and is released during arousal and stimulation.</p> <p>Release of NO causes smooth muscle relaxation. Then vascular resistance is decreased and blood inflows through arteries.</p> <p>Intracavernosal pressure is increased compresses veins causing entrapment of blood in corpora cavernosa = veno-occlusive mechanism. This causes the male penis to become rigid and the clitoris swollen. Pelvic floor contraction further increases pressure.</p> <p>Reduced arousal occurs with sympathetic stimulation that causes smooth muscle contraction, reduces blood flow, and releases veno-occlusive mechanism.</p> <p>Requires dominance of parasympathetic output via pelvic nerve. Also, some sympathetic nervous system involvement via hypogastric nerve.</p> <p>Autonomic and somatic neural pathways are involved during</p>	<p>After neurologic injury, it is important to remember that the entire body is sensitive to sexual touching with erogenous hotspots at the genitals, breasts, and anus.<sup>5</sup></p> <p>Libido is a complex combination of biological (hormone/neurotransmitter) and psychological factors (physical, emotional, contextual).<sup>5</sup></p> <p>Often individuals with disability, experience a lower libido or sexual desire.<sup>5</sup></p> <p>Sexual problems in men and women can include pain with arousal, pain with ejaculation/orgasm, pain during intercourse or penetrative activities (dyspareunia).<sup>5</sup></p> <p>Degrees of preservation of combined light touch and pinprick sensation within T11-L2 dermatomes helps predict those who will be capable of psychogenic arousal.<sup>5</sup></p> <p>Ejaculatory disorders are highly prevalent in male SCI patients and so fertility is a major issue.<sup>5</sup> Natural ejaculation is more likely in those with incomplete conus</p>
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	<p>activation, smooth muscle relaxation, and swelling)</p> <p>Nocturnal: during REM sleep (triggered by pontine reticular formation)</p>	<p>erection/vaginal lubrication is mediated by parasympathetic only.<sup>5</sup></p> <p>Ejaculation requires coordination of sympathetic (T11-L2) and parasympathetic (S2-S4) and somatic nervous system (pudendal nerve, S2-S5).<sup>5</sup></p>	<p>erection. Contraction of pelvic floor muscles (ischiocavernosus). Need intact bulbocavernosus reflex to achieve reflexogenic genital arousal.</p> <p><b>Ejaculation<sup>5</sup>:</b> T10 – L2 phenomena.</p> <p>Coordinated muscular and neurological event. Involves afferent sensory pathways; cerebral and spinal integrative, autonomic, and somatic centers; and efferent pathways. Accessory gland peristalsis is parasympathetic component and pelvic floor contraction is somatic component.</p> <p><b>Orgasm<sup>5</sup>:</b> Release of pelvic vasocongestion and neuromuscular tension (felt locally in genitalia and experienced as pleasure in brain)</p>	<p>medullaris or cauda equine lesions and is less likely in those with complete supraconal lesions.<sup>5</sup></p> <p>Potential Therapeutic Avenues<sup>5</sup>:</p> <ul style="list-style-type: none"> <li>- Preservation of somatic and autonomic pathways is critical to reestablish sexual function (similar to that of a person prior to their injury)</li> <li>- Mindfulness and fantasy techniques can be helpful to shift focus to remaining sensation.</li> <li>- Use of erogenous areas can also be incorporated.</li> <li>- Medications can be used to help with vasocongestion and increase topical sensation. (Better results in males versus females)</li> <li>- Principles of neuroplasticity, use of fantasy and mental sexual arousal (with or without a partner), combined with consistent and repetitive stimulation of a body part may allow for that to become a source of sexual arousal.</li> </ul> <p><b>Persons with SCI are people FIRST, and persons with SCI second.<sup>5</sup></b></p>
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## Bibliography

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