

v1: 8 August 2023

Review Article

Eroticism as a Hormetic Stimulus in Health and Ageing

Peer-approved: 8 August 2023

© The Author(s) 2023. This is an Open Access article under the CC BY 4.0 license.

Qeios, Vol. 5 (2023)
ISSN: 2632-3834

Marios Kyriazis¹

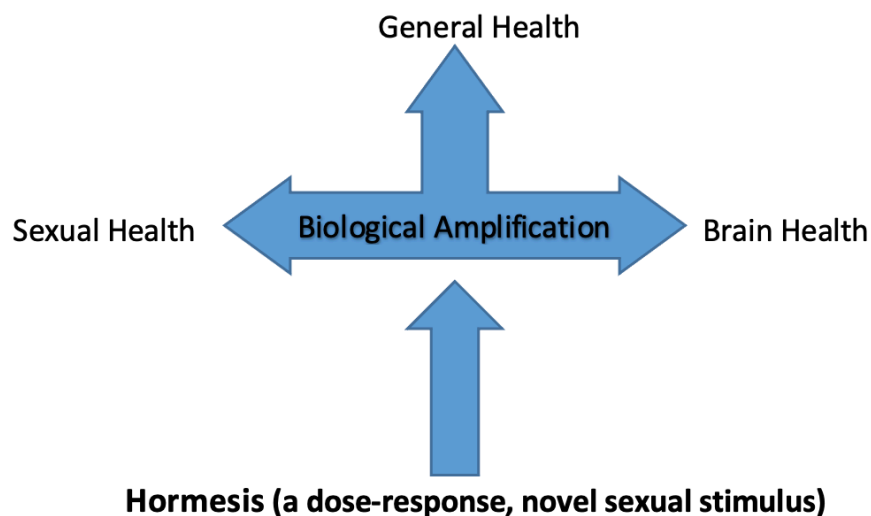
1. University of Catania, Italy

Eroticism in later life is, on the whole, a taboo subject, and the stigma attached to expressions of sexual intent by older people is widespread in most cultures. However, sexuality and eroticism have an important role to play in maintaining healthy ageing. Sexuality is an essential aspect of our biology, and its effects have repercussions in systems and organs other than the sexual. In this paper, I review the importance of developing a sexual-erotic element in later life, an element that is intimately coupled with the phenomenon of hormesis. In hormesis, there is a biological benefit following exposure to a mild stimulus or challenge, whereas exposure to a higher dose of the same stimulus becomes detrimental. Innovative sexual stimulation can be seen as a hormetic opportunity to initiate beneficial effects on the entire ageing human organism. The intention is to show that health benefits may be obtained not only through physical (exercise), nutritional, mental, or pharmacological challenges, but also through sexual stimulation of the appropriate magnitude and quality. By enhancing erotic stimulation, it may be possible to experience many other benefits spanning several domains such as the endocrine, immune, circulatory, and neurological. In addition, within an increasingly information-rich world, sexuality may play a part in improving adaptation to various cognitive external stimuli originating from our technological ecosystem.

Corresponding
drmarios@live.it

author:

Marios Kyriazis, Graphical Abstract



Highlights

- Hormesis operates within the sexual realm
- Innovative sexual stimulation leads to health improvements in later life
- Hormetic effects can be invoked via ‘sex hormetins’
- Inventive erotic activities may result in cognitive benefits

1. Introduction

Hormesis is a concept that is gaining increased importance in the biomedical and biological fields (Kyriazis, 2016). The concept was originally born in the field of toxicology, but it gained acceptance in many other disciplines. Clinically, the concept of hormesis is grounded on a basic principle, the ‘dose-response relationship’: exposure to low doses of a stimulus may result in beneficial health effects, whereas exposure to a higher dose of the same stimulus may result in detrimental effects. The stimulus can be physical, chemical, environmental, cognitive, etc. Here, I will review the evidence regarding an additional potential stimulus that may be capable of achieving a hormetic effect: that of sexuality (Kyriazis, 2010).

It is necessary to highlight that, in this paper, the terms ‘sexuality’ and ‘eroticism’ are used without making a distinction. Strictly, ‘sexuality’ is the primary urge to procreate, whereas ‘eroticism’ is also a reflection of other instincts or qualities such as lust, desire, emotion, and creativity. For the purposes of this discussion, it is

the stimulation quality that matters, and not merely the emotional element attached to such stimulation.

Although it is generally believed that ageing restricts sexual expression (Hernández Carrasco et al., 2018), it is nevertheless possible to experience some positive effects. For instance, after a long-term partner dies, the surviving partner may have an opportunity to explore other aspects of sexuality, even same-sex relationships (Wylie et al., 2013). Impediments to healthy sexual function in older life may include physical restrictions or pain due to arthritis, etc., lack of autonomy, and multiple side effects of drugs. In addition, lack of confidence and social exclusion play a role (Cybulski et al., 2018), as well as concerns about how expressions of sexuality may be perceived by society (Roney and Kazer, 2015). Nonetheless, it is possible to examine the subject of sexuality in later life with the intention of encouraging not only social expression but also actual physical contact, in order to promote both sexual and general health (Morton, 2017, Lindau et al., 2018).

2. Discussion

2.1. Sexuality and biological amplification

We know that sexual function has a variety of effects on several parts of the body, albeit many of these effects were shown specifically with penile-vaginal intercourse and less so with other forms of eroticism (Brody, 2010). Therefore, enhancing sexual activity and physical stimulation may result in various effects that do not always have an impact exclusively on the sexual system (Emerenziani et al., 2018). These effects may be

amplified and felt in other organs or systems through a process of biological amplification. Biological amplification is a phenomenon whereby the effects of a biological event that affects one organ may be sensed by and influence other organs or tissues distant from where the original event has taken place. It can also mean that the scale of the original stimulation has been magnified, and the result is enhanced compared to what would have been expected by considering only the magnitude of the original stimulation. For example, a reduction of sexual hormones (estrogens and testosterone) seen in ageing may be associated with an increased risk of Alzheimer's disease (Barron and Pike, 2012). Engagement in sexual activities in later life can increase the levels of these hormones and thus reduce the risk (Taziaux et al., 2007, Seredynski et al., 2013). It may be that sexual activities stimulate other aspects of our biology which, in turn, may reduce the risk of AD; however, this still needs further study.

2.2. Evidence of hormesis in sexuality

Research suggests that hormesis is involved in sexuality, at least in some animal models. For example, sublethal (hormetic) doses of the poison deltamethrin increase sexual behavior and responses to sex pheromones in insects (Lalouette et al., 2016), which is an adaptation effect of the insect to agricultural pesticides. In addition, mild oxidative stress improves sexual performance in the fruit fly (López-Martínez and Hahn, 2012) and results in a healthier lipid profile and mitochondrial function. Another study (Hirsh et al., 2003) showed an improvement in fecundity following exposure to low doses of lead, and a reduction in fecundity following exposure to higher levels of lead, a typical U-shaped non-linear (biphasic) dose-response relationship. Moreover, low doses of the mycotoxin Zearalenone in pre-pubertal dogs improve ovarian and uterine function and normalize metabolic processes (Gajęcka et al., 2015), whereas higher doses are toxic (Schoevers et al., 2012).

Autophagy, one of the hallmarks of hormesis, is involved in improving erectile dysfunction (Lin et al., 2018, Zhu et al., 2018), and it improves the synthesis of testosterone and sexual behaviour (Gao et al., 2018). These studies suggest that the general phenomenon of hormesis is present within the sexual realm and plays a role in defining sexual function (Kyriazis, 2010). Therefore, a stimulus that is novel (not routine and not predictable) and able to elicit an appropriate adaptive response, without causing damage, is defined as 'hormetic'.

Hormesis may be found in many aspects of eroticism. For instance, Abler et al. have described how exposure to mild ('low-dose') visual-erotic stimuli may produce significant hormonal effects on the brain, whereas a more direct and explicit exposure ('high-dose') does not result in significant effects on hormonal secretion or on brain activation patterns (Abler et al., 2013). This is typical of hormesis, where the dose required to produce a positive effect is constrained within certain boundaries and bears a 'U-shape' characteristic – neither too low nor too high. On the other hand, modest monotherapies (i.e., very 'low-dose' interventions) may not have significant effects either. In a study of vaginal electrical stimulation as a single, isolated (detached from environmental influences) intervention, it did not produce significant differences between the treatment group and the placebo group (Aydin et al., 2016). In this instance, it is shown that an insufficient level of stimulation (i.e., well below the critical level of a U-shaped relationship) does not produce any beneficial effects.

2.3. Magnitude and quality of stimulation

Sexual stimulation is subjected to principles common to any type of external stimulation. In this sense, stimulation is interpreted as a 'challenge,' i.e., a biological change in response to a perturbation. A 'challenge' is a situation that has value for an organism, so that the organism is inclined to act and adapt following exposure to any given external or even internal stimulus. In this sense, a challenge provokes appropriate action from the organism. One type of stimulation is breast (nipple) stimulation. This may be associated not only with sexual pleasure but also with a reduction in the risk of uterine, breast, endometrial, and ovarian cancers, and also with a reduction in the risk of depression and an increase in positive emotions (Robinson, 2015).

In devising practical interventions whereby clinicians may advise patients about sexual erotic (hormetic) stimulation, gender differences must be taken into account. For instance, it was shown that men have a preference for direct, crude exposure to sexuality, genitals, and intercourse, whereas women have a preference for emotional, structured, and softer erotic videos (Chung et al. 2013). It is important to also highlight that sexual behaviour is intricately connected to other pleasures, social interactions, and reward cycles. Therefore, achieving a hormetic level erotic state could also have repercussions on other aspects of behaviour and thus on brain function. This shows how important it is to consider the integration of hormetic

stimulation, i.e., not to rely on linear increments of activity but to follow the U-shaped principle (Georgiadis and Kringelbach, 2012).

Examples where a stimulus can be perceived as a positive challenge (i.e., a novelty, a stimulus that needs a response) are creative sexual practices such as:

- vibrotactile stimulation (Rowland, 2010, Panagiotopoulou et al., 2018) (e.g., innovative genital touching and masturbation, inventive use of vibrators or other devices, orgasmic meditation)
- visual erotic (Huynh et al., 2012, Wu et al., 2017) (e.g., legal pornography, motivating videos or voyeurism, 'top shelf' magazines, artistic sexual 'selfies')
- sex games (Faccio et al., 2014, Carlström, 2018) (e.g., mock Sadoomasochism, cross-dressing, inspiring sexual fantasies)
- uncommon sexual positions (Reynolds et al., 2015) (such as face sitting, or others inspired by Kama Sutra, for instance), and
- use of novelty aids (Rehor, 2015) (e.g., ridged condoms, rings, 'love balls,' G-spot stimulators, etc.).

In this respect, it is possible to create situations whereby a sexually charged challenge increases sensory and mental activity. The novelty of the stimulation is perceived as a challenge by neurons, and this may improve the adaptation of neuronal function, and endorphin, dopamine, and serotonin modulation (Uphouse, 2014, Hull et al., 2004).

A study of intrapersonal erotic touch has shown (Jönsson et al., 2015) that this can communicate emotions and erotic feelings when it is perceived as relatively weak (i.e., not unpleasant and not rough). This evokes notions of hormesis whereby the most benefit is derived from an application of a stimulus of a certain strength – not too much and not too little. In another study (Jiao et al., 2007) of 30 heterosexual males with no sexual dysfunction, it was shown that vibrotactile detection thresholds were reduced after watching erotic videos. In other words, sexual arousal was associated with increased sensitivity to vibrotactile stimulation, which indicates a synergistic effect. Thus, multiple sexual inputs must be taken into account because the hormetic threshold may be surpassed.

Both physical and imagined erotic stimulation may have a sexual effect. It was shown that both imagined and tactile self-stimulation of erotic areas such as the clitoris and the nipple activate several brain areas, whereas non-erotic stimulation (with a speculum) did not have such an effect (Wise et al., 2016). This underlines the importance of imagination in erotic stimulation and that there are various ways to achieve a

desired effect, something that may be of relevance to older people who lack a sexual partner.

2.4. Sexuality and cognition

There is some evidence suggesting that sexual activity is associated with improved cognition (Wright and Jenks, 2016, Freak-Poli et al., 2018), such as improved memory and executive function. Processing erotic information involves several realms, including memory, brain activation and coordination of signals, the circulatory system, and hormonal response (Parada et al., 2016). Erotic and non-erotic information involve different processing patterns in men compared to women. For instance, men are inclined to look longer at female erotic pictures, whereas women do not have such a bias: their preference is equal and uniform between opposite and same-sex pictures (Lykins, 2008). This underlines the difficulties in suggesting erotic stimulation to males who respond differently to the same stimulus compared to females.

Within an increasingly cognitive technological environment, it becomes necessary to examine ways to enhance cognitive function. One such way is through sexuality augmentation. For instance, it is known that Dehydroepiandrosterone (DHEA) improves neural function, and this is intimately connected to sexuality (Pluchino et al., 2015). Although sexuality and cognition are distinct functions, these are interrelated both peripherally and centrally in the brain (Motofei, 2011). Several cognitive processes are connected with sexuality, and it is known that novel external stimulation (visual, tactile, etc.) as well as abstract/social stimuli are integrated through the ascending reticular activating system to reach several neuronal structures, including the thalamus, hypothalamus, and cortex (Motofei and Rowland, 2014), coupling the sexual and the cognitive systems. Another example underlying the common frontiers between sexuality and cognition can be appreciated by studying the dynamics of tibolone treatment (Genazzani et al., 2006). Tibolone is used for the management of menopausal symptoms, has progestogenic and androgenic effects, and affects mood, libido, and cognition. It protects against cognitive decline in postmenopausal women even during short-term treatment (Pinto-Almazán, et al., 2017). The relationship between cognition and sexuality is further highlighted by the example of the drug Modafinil. This is used as a general cognitive enhancer (Murillo-Rodríguez et al., 2018), but it has also been reported that it enhances sexuality (Swapnajeet et al., 2016).

Therefore, hormetic sexual stimulation may be another form of achieving cognitive enhancement.

2.5. 'Sex hormetins'

Hormetins are chemical substances that initiate the stress response, in the sense that they invoke the phenomenon of hormesis (Rattan, 2012). Compounds that may mimic certain physiological aspects of sexuality may be classified as 'sex hormetins'. The study of sex hormetins (or 'sex mimetics') is based on the concept of a pharmacological extension of the hormetic sexual techniques discussed above.

A candidate sex hormetin is the pluripotent agonist of the serotonin 5-HT_{1A} receptor, Flibanserin. This is approved specifically for use in HSDD (Hypoactive Sexual Desire Disorder), which is the most common form of female sexual dysfunction (Jaspers et al., 2016). Flibanserin increases the number of gratifying sexual events in pre- and post-menopausal women (Stahl, 2015). Its functions exhibit a 'U-shaped', dose-response pattern: its clinical and pharmacological effects depend on the dose used in each situation. Another sex mimetic is Anandamide, an endocannabinoid that modulates neurotransmitter release and has been linked to an improvement of sexual behaviour in animals (Canseco-Alba and Rodríguez-Manzo, 2013). It increases mounting episodes, intromission, ejaculation, and resumption of copulation following ejaculation (Rodríguez-Manzo and Canseco-Alba, 2015). We know that there is cross-talk between the endocannabinoid and the immune systems (Boorman et al., 2016), where this multifaceted relationship may affect inflammation response, depression, and immunocompetence. This is an example of biological amplification mentioned above. A third sex hormetin is Dapoxetine, a selective serotonin reuptake inhibitor and antidepressant, which is also used in the treatment of premature ejaculation. In a typical hormetic fashion, a moderate dose of Dapoxetine is clinically useful, while a higher dosage is harmful, and a very low dose is ineffective (El Mazoudi et al, 2015). This highlights the hormetic, dose-response action of Dapoxetine and reminds us once more of the importance of regulating the degree of challenging stimulation. Moderately low doses of these compounds are sensed as a pharmacological challenge by the target organs. This upregulates the stress response and improves cross-talk between different domains such as the immune system, neuronal structures, and endocrine organs.

3. Conclusions

Hormesis plays a role in sexual function, and this has effects that are amplified in order to influence other organs and tissues. In terms of practical conclusions, reasonable advice stemming from the above discussion could be to encourage personal expression of sexuality in ageing, accept and encourage other older people to express their own sexuality, and pursue a sexual life that is at the outer limit of one's comfort zone (i.e., challenging but pleasant) (Skalacka and Gerymski, 2018). In order for the hormetic effect to take place, routine and boredom must be avoided, and the activities should be creative, rousing, novel, and able to elicit a biological response. Sexuality and eroticism may be used as tools that can enhance not only sexual health in later life but also brain function, cognition, and overall clinical health.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

- Abler, B., Kumpfmüller, D., Grön, G., et al., 2013. Neural correlates of erotic stimulation under different levels of female sexual hormones. *PLoS One*. 8(2):e54447
- Aydın, S., Arıoğlu Aydın, Ç., Batmaz, G., Dansuk, R., 2015. Effect of vaginal electrical stimulation on female sexual functions: a randomized study. *J Sex Med*. 12(2):463–9. doi: 10.1111/jsm.12788
- Barron, A.M., Pike, C.J., 2012. Sex hormones, aging, and Alzheimer's disease. *Front Biosci (Elite Ed)*. 4:976–97
- Boorman, E., Zajkowska, Z., Ahmed, R., Pariente, C.M., Zunszain, P.A., 2016. Crosstalk between endocannabinoid and immune systems: a potential dysregulation in depression? *Psychopharmacology (Berl)*. 233(9):1591–604. doi: 10.1007/s00213-015-4105-9
- Brody, S., 2010. The relative health benefits of different sexual activities. *J Sex Med*. 7(4 Pt 1):1336–61. doi: 10.1111/j.1743-6109.2009.01677.x
- Canseco-Alba, A., Rodríguez-Manzo, G., 2013. Anandamide transforms noncopulating rats into sexually active animals. *J Sex Med*. 10(3): 686–93
- Carlström C. BDSM, becoming and the flows of desire. *Cult Health Sex*. 2018:1-11. doi: 10.1080/13691058.2018.1485969. [Epub ahead of print]
- Chung, W.S., Lim, S.M., Yoo, J.H., Yoon, H., 2013. Gender difference in brain activation to audio-visual sexual stimulation; do women and men experience

the same level of arousal in response to the same video clip? *Int J Impot Res.* 25(4):138-42. doi: 10.1038/ijir.2012.47

- Cybulski M, Cybulski L, Krajewska-Kulak E, Orzechowska M, Cwalina U, Jasinski M. Sexual Quality of Life, Sexual Knowledge, and Attitudes of Older Adults on the Example of Inhabitants Over 60s of Bialystok, Poland. *Front Psychol.* 2018;9:483. doi: 10.3389/fpsyg.2018.00483.
- ElMazoudy, R., AbdelHameed, N., ElMasry, A., 2015. Paternal dapoxetine administration induced deterioration in reproductive performance, fetal outcome, sexual behavior and biochemistry of male rats. *Int J Impot Res.* 27(6):206-14. doi: 10.1038/ijir.2015.16
- Emerenziani GP, Izzo G, Vaccaro MG, Quattrone A, Lenzi A, Aversa A. Gender difference and correlation between sexuality, thyroid hormones, cognitive, and physical functions in elderly fit. *J Endocrinol Invest.* 2018 Nov 7. doi: 10.1007/s40618-018-0974-1. [Epub ahead of print]
- Faccio, E., Casini, C., Cipolletta, S., 2014. Forbidden games: the construction of sexuality and sexual pleasure by BDSM 'players'. *Cult Health Sex.* 16(7): 752-64
- Freak-Poli R, Licher S, Ryan J, Ikram MA, Tiemeier H. Cognitive Impairment, Sexual Activity and Physical Tenderness in Community-Dwelling Older Adults: A Cross-Sectional Exploration. *Gerontology.* 2018;64(6):589-602. doi: 10.1159/000490560
- Gao F, Li G, Liu C, et al. Autophagy regulates testosterone synthesis by facilitating cholesterol uptake in Leydig cells. *J Cell Biol.* 2018; 217(6):2103-2119. doi: 10.1083/jcb.201710078
- Gajęcka, M., Zielonka, Ł., Gajęcki, M. 2015. The Effect of Low Monotonic Doses of Zearalenone on Selected Reproductive Tissues in Pre-Pubertal Female Dogs-- A Review. *Molecules.* 20(11):20669-87. doi: 10.3390/molecules201119726
- Genazzani, A.R., Pluchino, N., Bernardi, F., et al., 2006. Beneficial effect of tibolone on mood, cognition, well-being, and sexuality in menopausal women. *Neuropsychiatr Dis Treat.* 2(3):299-307
- Georgiadis, J.R., Kringelbach, M.L., 2012. The human sexual response cycle: brain imaging evidence linking sex to other pleasures. *Prog Neurobiol.* 98(1):49-81. doi: 10.1016/j.pneurobio.2012.05.004
- Hernández Carrasco M, de la Fuente Ballesteros SL, García Granja N, Hidalgo Benito A, García Álvarez I, Cano Pazos M. Characteristics of the sexual sphere in elderly patients. *Semergen.* 2018 Nov 5. pii: S1138-3593(18)30378-2. doi: 10.1016/j.semerg.2018.09.007. Epub ahead of print
- Hirsch, H.V., Mercer, J., Sambaziotis, H., et al. 2003. Behavioral effects of chronic exposure to low levels of lead in *Drosophila melanogaster*. *Neurotoxicology.* 24(3):435-42
- Hull, E.M., Muschamp, J.W., Sato, S., 2004. Dopamine and serotonin: influences on male sexual behavior. *Physiol Behav.* 83(2):291-307
- Huynh, H.K., Beers, C., Willemsen, A., et al., 2012. High-intensity Erotic Visual Stimuli De-activate the Primary Visual Cortex in Women. *J Sexual Med.* 9(6): 1579-1587
- Jaspers, L., Feys, F., Bramer, W.M., et al., 2016. Efficacy and Safety of Flibanserin for the Treatment of Hypoactive Sexual Desire Disorder in Women: A Systematic Review and Meta-analysis. *JAMA Intern Med.* 176(4):453-62. doi: 10.1001/jamainternmed.2015.8565
- Jiao, C., Knight, P.K., Weerakoon, P., Turman, A.B., 2007. Effects of visual erotic stimulation on vibrotactile detection thresholds in men. *Arch Sex Behav.* 36(6):787-92
- Jönsson, E.H., Backlund Wasling, H., Wagnbeck, V., et al., 2015. Unmyelinated tactile cutaneous nerves signal erotic sensations. *J Sex Med.* 12(6):1338-45. doi: 10.1111/jsm.12905
- Kyriazis, M., 2010. Nonlinear stimulation and hormesis in human aging: practical examples and action mechanisms. *Rejuvenation Res.* 13(4):445-52
- Kyriazis, M., 2016. Challenging Aging: The Anti-senescence Effects of Hormesis, Environmental Enrichment, and Information Exposure. In *Book Series: Frontiers in Aging Sciences. Volume 1*, Bentham Science UAE. DOI: 10.2174/97816810833531160101
- Lalouette, L., Pottier, M.A., Wycke, M.A., et al. 2016. Unexpected effects of sublethal doses of insecticide on the peripheral olfactory response and sexual behavior in a pest insect. *Environ Sci Pollut Res Int.* 23(4):3073-85. doi: 10.1007/s11356-015-5923-3
- Lin H, Wang T, Ruan Y, et al. Rapamycin supplementation may ameliorate erectile function in rats with streptozotocin-induced type 1 diabetes by inducing autophagy and inhibiting apoptosis, endothelial dysfunction, and corporal fibrosis. *J Sex Med* 2018;15:1246-1259
- Lindau ST, Dale W, Feldmeth G, Gavrilova N, Langa KM, Makelarski JA, Wroblewski K. Sexuality and Cognitive Status: A U.S. Nationally Representative Study of Home-Dwelling Older Adults. *J Am Geriatr Soc.* 2018;66(10):1902-1910. doi: 10.1111/jgs.15511
- López-Martínez, G., Hahn, D.A., 2012. Short-term anoxic conditioning hormesis boosts antioxidant defenses, lowers oxidative damage following

- irradiation and enhances male sexual performance in the Caribbean fruit fly, *Anastrepha suspensa*. *J Exp Biol*.215(Pt 12):2150–61. doi: 10.1242/jeb.065631
- Lykins, A.D., Meana, M., Strauss, G.P., 2008. Sex differences in visual attention to erotic and non-erotic stimuli. *Arch Sex Behav*. 37(2):219–28
 - Morton L. Sexuality in the Older Adult. *Prim Care*. 2017;44(3):429–438. doi: 10.1016/j.pop.2017.04.004.
 - Motofei, I.G., 2011. A dual physiological character for cerebral mechanisms of sexuality and cognition: common somatic peripheral afferents. *BJU Int*. 108(10):1634–9. doi: 10.1111/j.1464-410X.2011.10116.x
 - Motofei, I.G., Rowland, D.L., 2014. The ventral-hypothalamic input route: a common neural network for abstract cognition and sexuality. *BJU Int*. 113(2):296–303 doi: 10.1111/bju.12399
 - Murillo-Rodríguez E, Barciela Veras A, Barbosa Rocha N, Budde H, Machado S. An Overview of the Clinical Uses, Pharmacology, and Safety of Modafinil. *ACS Chem Neurosci*. 2018;9(2):151–158. doi: 10.1021/acscchemneuro.7b00374
 - Panagiotopoulou E, Filippetti ML, Gentsch A, Fotopoulou A. Dissociable sources of erogeneity in social touch: Imagining and perceiving C-Tactile optimal touch in erogenous zones. *PLoS One*. 2018;13(8):e0203039. doi: 10.1371/journal.pone.0203039
 - Parada, M., Gérard, M., Larcher, K., Dagher, A., Binik, Y.M., 2016. Neural Representation of Subjective Sexual Arousal in Men and Women. *J Sex Med*. 13(10):1508–22. doi: 10.1016/j.jsxm.2016.08.008
 - Pinto-Almazán, R., Segura-Urbe, J.J., Farfán-García, E.D., Guerra-Araiza, C., 2017. Effects of Tibolone on the Central Nervous System: Clinical and Experimental Approaches. *Biomed Res Int*. 2017;2017:8630764. doi: 10.1155/2017/8630764
 - Pluchino, N., Drakopoulos, P., Bianchi-Demicheli, F. et al., 2015. Neurobiology of DHEA and effects on sexuality, mood and cognition. *J Steroid Biochem Mol Biol*. 145:273–80
 - Rattan, S.I., 2012. Rationale and methods of discovering hormetins as drugs for healthy ageing. *Expert Opin Drug Discov*. 7(5):439–48. doi: 10.1517/17460441.2012.677430
 - Rehor, J.E., 2015. Sensual, Erotic, and Sexual Behaviors of Women from the “Kink” Community. *Archives of Sexual Behavior*. 44(4): 825–836
 - Reynolds, G.L., Fisher, D.G., Rogala, B., 2015. Why Women Engage in Anal Intercourse: Results from a Qualitative Study. *Archives of Sexual Behavior*. 44(4): 983–995
 - Robinson, V.C., 2015. Support for the hypothesis that sexual breast stimulation is an ancestral practice and a key to understanding women's health. *Med Hypotheses*. 85(6):976–85. doi: 10.1016/j.mehy.2015.09.002
 - Rodríguez-Manzo, G., Canseco-Alba, A., 2015). Anandamide reduces the ejaculatory threshold of sexually sluggish male rats: possible relevance for human lifelong delayed ejaculation disorder. *J Sex Med*. 12(5): 1128–35
 - Roney, L., Kazer, M.W., 2015. Geriatric sexual experiences: The seniors tell all. *Appl Nurs Res*. 28(3):254–6. doi: 10.1016/j.apnr.2015.04.005
 - Rowland, D.L., 2010). Genital and Heart Rate Response to Erotic Stimulation in Men with and without Premature Ejaculation. *Int J Impot Res*. 22: 318–32
 - Schoevers, E.J., Santos, R.R., Colenbrander, B., Fink-Gremmels, J., Roelen, B.A.J., 2012. Transgenerational toxicity of Zearalenone in pigs. *Reproductive Toxicol*. 34 (1): 110–119. doi:10.1016/j.reprotox.2012.03.004
 - Serebinski, A.L., Balthazart, J., Christophe, V.J., Ball, G.F., Cornil, C.A., 2013. Neuroestrogens rapidly regulate sexual motivation but not performance *J Neurosci*. 33(1):164–74. doi: 10.1523/JNEUROSCI.2557-12.2013
 - Skołacka K, Gerymski R. Sexual activity and life satisfaction in older adults. *Psychogeriatrics*. 2018 Oct 7. doi: 10.1111/psyg.12381. [Epub ahead of print]
 - Stahl, S.M., 2015. Mechanism of action of flibanserin, a multifunctional serotonin agonist and antagonist (MSAA), in hypoactive sexual desire disorder. *CNS Spectr*. 20(1): 1–6
 - Swapnajeet, S, Subodh BN, Gourav G. Modafinil Dependence and Hypersexuality: A Case Report and Review of the Evidence. *Clin Psychopharmacol Neurosci*. 2016; 14(4): 402–404. doi: 10.9758/cpn.2016.14.4.402
 - Taziaux, M., Keller, M., Bakker, J., Balthazart, J., 2007. Sexual behavior activity tracks rapid changes in brain estrogen concentrations. *J Neurosci*. 27(24):6563–72
 - Uphouse, L., 2014. Pharmacology of serotonin and female sexual behavior. *Pharmacol Biochem Behav*. 121:31–42. doi: 10.1016/j.pbb.2013.11.008
 - Wise, N.J., Frangos, E., Komisaruk, B.R., 2016. Activation of sensory cortex by imagined genital stimulation: an fMRI analysis. *Socioaffect Neurosci Psychol*. 6:31481. doi: 10.3402/snp.v6.31481. eCollection 2016
 - Wright, H., Jenks, R.A., 2016. Sex on the brain! Associations between sexual activity and cognitive function in older age. *Age Ageing*. 45 (2): 313–317. DOI: <https://doi.org/10.1093/ageing/afv197>

- Wu SL, Chow MSM, L JY, Yang J, Zhou H, Yew DT. Visual Sexual Stimulation and Erection, a Brief Review with New fMRI Data. Curr Med Chem. 2017;24(11):1139-1146. doi: 10.2174/0929867323666161213102528
- Wylie, K.R., Wood, A., McManus, R. 2013. Sexuality and old age. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz. 56(2):223-30. doi: 10.1007/s00103-012-1602-4
- Zhu GQ, Jeon SH, Bae WJ, Choi SW et al. Efficient Promotion of Autophagy and Angiogenesis Using Mesenchymal Stem Cell Therapy Enhanced by the Low-Energy Shock Waves in the Treatment of Erectile Dysfunction. Stem Cells Int. 2018; 2018:1302672. doi: 10.1155/2018/1302672.

Declarations

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.