
SYMPTOMS

HORMONES

Imbalances in estrogen, progesterone and testosterone, can affect the inner ear.

ARTICLE

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Sex Hormones & The Inner Ear

By Neil Monaghan & Habib Rizk MD- Department of Otolaryngology - Head and Neck Surgery, Medical University of South Carolina

OVERVIEW OF THE INNER EAR

The inner ear is a complex structure that has functions that are necessary for hearing and balance. In order to hear, sound travels from the environment through the external ear and ear canal. Sound then passes through the eardrum and into the middle ear, where it is amplified by the middle ear ossicles. This vibration is then transmitted to the cochlea, in the inner ear. Once in the inner ear, sound is transduced by the cochlea into electrical impulses which the brain interprets as sound. Balance is achieved through the detection of linear and rotational acceleration by the vestibular system, which relays this information to the brain.

ANATOMY OF THE INNER EAR

The anatomy of the inner ear includes the cochlea, the three semicircular canals, the utricle, and the saccule. The cochlea, as previously mentioned, enables hearing by transducing sound waves to the brain. The vestibular system functions to help humans balance, and is made up of the utricle, the saccule, and three semicircular canals. Linear movement is detected by the utricle and saccule. The former detects horizontal movement, while the latter detects vertical movement. The semicircular canals sense rotational movement of the head. The inner ear apparatus relays information to the brainstem via the 8th Cranial nerve, also referred to as the vestibulocochlear nerve.

SEX HORMONES

Sex Hormones are steroid hormones that are primarily produced in the gonads, and to a lesser extent in the



adrenal glands and adipose tissue. They are responsible for many differences in appearance and function of the sexes in humans and other organisms. There are three major sex hormones: estrogen, progesterone, and testosterone. Estrogen and Progesterone traditionally dominate in the female, and testosterone traditionally dominates in the male. These hormones rise and fall physiologically, with estrogen and progesterone rising and falling with the female menstrual cycle.

The production of sex hormones in both sexes rises into sexual maturity, peaking in the late 20s to early 30s. Levels then fall steadily, falling to very low levels in the 7th and 8th decades and beyond.

SEX HORMONES AND THE INNER EAR

The balance of Estrogen, Progesterone, and Testosterone is necessary for proper auditory and vestibular function of the inner ear and hormonal imbalance has been implicated in various symptoms related to the inner ear although the pathophysiology and the mechanism of the hormonal influence are not completely elucidated.

Estrogen

Estrogen is generally thought to be protective for the inner ear functions of hearing and balance, as supported by both observational studies in humans and basic science research. Estrogen may slow the deterioration of hearing in older individuals, and it also generally appears to modulate the number and severity of episodes of vestibular symptoms in pathologies such as Meniere's disease

and Vestibular Migraine. This is also supported by observations of hearing and balance during the menstrual cycle and menopause. We know that in the absence of estrogen—as evidenced in postmenopausal women—disorders of hearing and balance are much more common. Furthermore, in reproductive-aged women that have recurrent vestibular episodes get them more commonly during the low-estrogen periods of their cycle,

right before their period. These findings support the thought that estrogen has a beneficial effect on functions of balance and hearing.

Progesterone

Progesterone and related progestins, on the other hand, appear to have a negative effect on auditory function. There is limited data on the effect of progestins on vestibular function, but older women on

progestin-containing hormone replacement therapy tend to have poorer hearing. Specifically, it seems to hurt people's ability to hear in noisy environments. Additionally, progesterone is at extremely high levels during pregnancy, where a reversible, low frequency hearing loss has been reported. Other uncommon audiological complaints of pregnancy include ringing in the ears and sudden onset sensorineural hearing loss. There is still much to learn about the role of Progestins in the function of the inner ear.

Testosterone

As little as we know about progestins, we may know less about the role of

THE BALANCE OF ESTROGEN, PROGESTERONE, AND TESTOSTERONE IS NECESSARY FOR PROPER AUDITORY AND VESTIBULAR FUNCTION OF THE INNER EAR.



testosterone in hearing and balance. What we do know is that it appears to have a harmful effect on hearing, specifically in the high pitch range. This is evidenced by both studies of men and studies of women with polycystic ovarian syndrome, who are known to have higher levels of testosterone-like hormones in their bloodstream. Like progestins, we have much to learn about the role of testosterone in the inner ear. While all those studies suggest an association between the levels of sex hormones and the inner ear pathologies, they cannot confirm causality.

ARE THERE DIFFERENCES IN INNER EAR FUNCTION BETWEEN MEN AND WOMEN?

There are several differences observed between the sexes. The differences are generally assumed to be due to differences in circulating estrogen levels. Men appear to be more sensitive to lower pitched sounds, where women appear to be more sensitive to high pitched sounds. Men are more likely to report tinnitus, and they have more intense age-related hearing loss. Women are more likely to have recurrent vestibulopathies such as Meniere's disease, vestibular migraine, and benign paroxysmal positional vertigo.

ROLE OF SEX HORMONES IN AUDITORY AND VESTIBULAR PATHOLOGY

Presbycusis

This is age-related hearing loss. Patients lose sensitivity to sound and typically have trouble with understanding speech in noisy environments. Hearing declines in all frequencies with age in both sexes, however, it declines more rapidly in men and declines more slowly in women taking estrogen-containing hormone replacement

therapy. Men perform more poorly than women, however, in all hearing categories. The presumption is that older individuals have very low levels of estrogen, so hearing deteriorates quickly in its absence and more so in older men.

Benign Paroxysmal Positional Vertigo (BPPV)

BPPV is a disorder where brief episodes of dizziness come on usually following changes to head position. Estrogen appears to be important in preventing the development of BPPV. This disorder is more common in women, especially after menopause, and women receiving estrogen therapy tend to develop BPPV less frequently, supporting the theory that estrogen deficiency is a risk factor for the disorder. Interestingly, 3/4 of women that have BPPV also have either osteopenia or osteoporosis, which are also associated with estrogen deficiency. Multiple studies have also shown a relationship between low levels of vitamin D and recurrent BPPV. Women after menopause tend to have lower levels of vitamin D.

Otosclerosis

Otosclerosis is a disorder of aberrant, excessive bone growth within the middle ear. Estrogens are thought to worsen otosclerosis because they promote bone growth by inhibiting its breakdown. It is reported to be associated with and worsen during periods of high estrogen, like pregnancy and when people are receiving estrogen therapy. It is also twice as likely to occur in females.

Meniere's Disease (MD)

MD is a disorder characterized by episodic hearing loss, tinnitus, aural fullness, and dizziness. It is associated with too much fluid buildup in the inner ear, called



“endolymphatic hydrops.” This fluid may be responsive to changes in hormones. When estrogen is low, as in the premenstrual phase of the menstrual cycle, there is more fluid accumulation in the inner ear. Female MD patients have more attacks during the premenstrual period according to some reports and this could be the reason why.

Vestibular Migraine (VM)

Vestibular migraine is the most frequent cause of vertigo. It is also much more frequent in women after menopause.

Mal de Debarquement Syndrome (MdDS)

MdDS is a central vestibular syndrome where patients often feel like they’re rocking or swaying as they might if they were in a boat. Estrogen fluctuations also seem to effect MdDS. This syndrome is much more common in females and usually develops around the time of menopause, when estrogen levels are falling to a very low level.

CONCLUSIONS

Sex hormones and their respective concentrations are thought to play a role in the functions of the inner ear. Estrogen may be protective for hearing. In addition, low estrogen levels may put patients at risk for developing vestibular disorders or trigger symptoms in otherwise predisposed individuals. In addition, it may be associated with an increased risk for disorders such as otosclerosis, suggesting that the effects of sex hormones are much more nuanced and probably depend on a variety of other factors. Much less is known about the effects of progesterone and testosterone, however. Patients experiencing age-related or other inner ear syndromes may benefit from a comprehensive hormonal evaluation in the event there is a hormonal disturbance that

is contributing to their presentation

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