FOLLICLE-STIMULATING HORMONE

Fsh

FSH is a hormone secreted by the anterior pituitary gland. It regulates the development, growth, pubertal maturation and reproductive functions of the body.

About Follicle-stimulating hormone

Function

Follicle-stimulating hormone (FSH) (Pic.1) is a gonadotropin, a glycoprotein polypeptide hormone. FSH is synthesized and secreted by the gonadotropic cells of the anterior pituitary gland, and regulates the development, growth, pubertal maturation, and reproductive processes of the body. FSH and luteinizing hormone (LH) work together in the reproductive system.

Regulation

FSH regulates the development, growth, pubertal maturation and reproductive processes of the human body:

In males

Follicle-stimulating hormone stimulates both the production of androgen-binding protein by Sertoli cells, and the formation of the blood-testis barrier. Androgen-binding protein is essential to concentrating testosterone in levels high enough to initiate and maintain spermatogenesis, which can be 20-50 times higher than the concentration found in blood. Follicle-stimulating hormone may initiate the sequestering of testosterone in the testes, but once developed, only testosterone is required to maintain spermatogenesis. However, increasing the levels of follicle-stimulating hormone will increase the production of spermatozoa by preventing the apoptosis of type A spermatogonia. The hormone inhibin acts to decrease the levels of follicle-stimulating hormone. Studies from rodent models suggest that gonadotropin hormones (both LH and FSH) support the process of spermatogenesis by suppressing the proapoptotic signals and, therefore, promote spermatogenic cell survival.

In females

FSH stimulates the growth and recruitment of immature ovarian follicles in the ovary. In early (small) antral follicles, FSH is the major survival factor that rescues the small antral follicles (2-5 mm in diameter for humans) from apoptosis (programmed death of the somatic cells of the follicle and oocyte). In the luteal-follicle phase transition period the serum levels of progesterone and estrogen (primarily estradiol) decrease and no longer suppress the release of FSH, consequently FSH peaks at about day three (day one is the first day of menstrual flow) (Pic. 2). The cohort of small antral follicles is normally sufficiently in number to produce enough Inhibin B to lower FSH serum levels. (As a woman nears perimenopause, the number of small antral follicles recruited in each cycle diminishes and consequently insufficient Inhibin B is produced to fully lower FSH and the serum level of FSH begins to rise. Eventually the FSH level becomes so high that downregulation of FSH receptors occurs and by postmenopause any remaining small secondary follicles no longer have FSH nor LH receptors).

In addition, there is evidence that gonadotrophin surge-attenuating factor produced by small follicles during the first half of the follicle phase also exerts a negative feedback on pulsatile luteinizing hormone (LH) secretion amplitude, thus allowing a more favorable environment for follicle growth and preventing premature luteinization.
When the follicle matures and reaches 8-10 mm in diameter it starts to secrete significant amounts of estradiol. Normally in humans only one follicle becomes dominant and survives to grow to 18-30 mm in size and ovulate, the remaining follicles in the cohort undergo atresia. The sharp increase in estradiol production by the dominant follicle (possibly along with a decrease in gonadotrophin surge-attenuating factor) cause a positive effect on the hypothalamus and pituitary and rapid GnRH pulses occur and an LH surge results. The increase in serum estradiol levels cause a decrease in FSH production by inhibiting GnRH production in the hypothalamus.

The decrease in serum FSH level causes the smaller follicles in the current cohort to undergo atresia as they lack sufficient sensitivity to FSH to survive. Occasionally two follicles reach the 10 mm stage at the same time by chance and as both are equally sensitive to FSH both survive and grow in the low FSH environment and thus two ovulations can occur in one cycle possibly leading to non-identical (dizygotic) twins.

Measurement of FSH level

Follicle stimulating hormone is typically measured in the early follicular phase of the menstrual cycle, usually day three to five, counted from last menstruation. At this time, the levels of estradiol (E2) and progesterone are at the lowest point of the menstrual cycle. FSH levels in this time is often called basal FSH levels, to distinguish from the increased levels when approaching ovulation. FSH levels are normally low during childhood and, in females, high after menopause (Pic. 3).

High FSH levels

The most common reason for high serum FSH concentration is in a female who is undergoing or has recently undergone menopause. High levels of Follicle-Stimulating Hormone indicate that the normal restricting feedback from the gonad is absent, leading to an unrestricted pituitary FSH production.

If high FSH levels occur during the reproductive years, it is abnormal. Conditions with high FSH levels include:

- Premature menopause also known as Premature Ovarian Failure
- Poor ovarian reserve also known as Premature Ovarian Aging
- Gonadal dysgenesis
- Turner syndrome
- Castration
- Swyer syndrome
- Certain forms of CAH
- Testicular failure
- Klinefelter syndrome
- Systemic Lupus Erythematosus also known as Lupus

Most of these conditions are associated with subfertility and/or infertility. Therefore, high FSH levels are an indication of subfertility and/or infertility.

Low FSH levels

Diminished secretion of FSH can result in failure of gonadal function (hypogonadism). This condition is typically manifested in males as failure in production of normal numbers of sperm. In females, cessation of reproductive cycles is commonly observed. Conditions with very low FSH secretions are:

- Polycystic Ovarian Syndrome
- Polycystic Ovarian Syndrome + Obesity + Hirsutism + Infertility
- Kalimann syndrome
- Hypothalamic suppression
- Hypopituitarism
- Hyperprolactinemia
- Gonadotropin deficiency
- Gonadal suppression therapy

Use for infertility therapy

FSH is used commonly in infertility therapy, mainly for ovarian hyperstimulation as part of IVF. In some cases, it is used for reversal of anovulation as well. FSH is available mixed with LH activity in various menotropins including more purified forms of urinary gonadotropins such as Menopur, as well as without LH activity as recombinant FSH (Gonapure, Gonal F, Follistim, Folitropin alpha).
Find more about related issues

Diagnoses

Amenorrhoea
The absence of a menstrual period in women of reproductive age.
Learn more at: www.fertilitypedia.org/therapy/diag/amenorrhoea

Anorexia Nervosa
An eating disorder characterized by the maintenance of a body weight below average, fear of gaining weight, and a distorted body image.
Learn more at: www.fertilitypedia.org/therapy/diag/anorexia-nervosa

Anovulation
Failure of the ovaries to release an oocyte over a period of time generally exceeding 3 months.
Learn more at: www.fertilitypedia.org/therapy/diag/anovulation

Azoospermia
Complete absence of sperm in the ejaculate of a man.
Learn more at: www.fertilitypedia.org/therapy/diag/azoospermia

Cryptozoospermia
Male infertility diagnosis characterized by extremely low concentration of sperm in semen.
Learn more at: www.fertilitypedia.org/therapy/diag/cryptozoospermia

Ejaculatory disorders
A class of sexual disorders defined as the subjective lack of normal ejaculation.
Learn more at: www.fertilitypedia.org/therapy/diag/ejaculatory-disorders

Erectile dysfunction
The inability (that lasts more than 6 months) to develop or maintain an erection of the penis during sexual activity.
Learn more at: www.fertilitypedia.org/therapy/diag/erectile-dysfunction

Hyperprolactinemia
The presence of abnormally high levels of prolactin in the blood.
Learn more at: www.fertilitypedia.org/therapy/diag/hyperprolactinemia

Hypogonadism
A medical term which describes a diminished functional activity of the gonads – the testes and ovaries.
Learn more at: www.fertilitypedia.org/therapy/diag/hypogonadism

Idiopathic male infertility
A condition in which fertility impairment occurs spontaneously or due to an unknown cause.
Learn more at: www.fertilitypedia.org/therapy/diag/idiopathic-male-infertility

Kallmann syndrome
A genetic condition where the primary symptom is a failure to start puberty or a failure to fully complete puberty.
Learn more at: www.fertilitypedia.org/therapy/diag/kallmann-syndrome

Luteinised unruptured follicle syndrome
The luteinisation of ovulatory follicle without a release of an oocyte.
Learn more at: www.fertilitypedia.org/therapy/diag/luteinised-unruptured-follicle-syndrome
Menopause
The time in most women's lives when menstrual periods stop permanently, and the woman is no longer able to have children. Learn more at: www.fertilitypedia.org/therapy/diag/menopause

Menstrual cycle disorders
An abnormal condition in a woman’s menstrual cycle. Learn more at: www.fertilitypedia.org/therapy/diag/menstrual-cycle-disorders

Non-obstructive azoospermia
Complete absence of sperm in the ejaculate due to testicular failure. Learn more at: www.fertilitypedia.org/therapy/diag/non-obstructive-azoospermia

Oligomenorrhea
Light or infrequent menstrual flow at intervals of 39 days to 6 months or 5–7 cycles in a year. Learn more at: www.fertilitypedia.org/therapy/diag/oligomenorrhea

Oligozoospermia
Semen with a low concentration of sperm and is a common finding in male infertility. Learn more at: www.fertilitypedia.org/therapy/diag/oligozoospermia

Polycystic ovary syndrome
A condition in which a woman has an imbalance of female sex hormones. This may lead to changes in the menstrual cycle, cysts in the ovaries, trouble g Learn more at: www.fertilitypedia.org/therapy/diag/polycystic-ovary-syndrome

Poor ovarian reserve
A condition of low fertility characterized by low numbers of remaining oocytes in the ovaries or possibly impaired oocyte development or recruitment. Learn more at: www.fertilitypedia.org/therapy/diag/poor-ovarian-reserve

Premature ovarian failure
The loss of function of the ovaries before age 40. Learn more at: www.fertilitypedia.org/therapy/diag/premature-ovarian-failure

Prostatitis
An inflammation of the prostate gland. Learn more at: www.fertilitypedia.org/therapy/diag/prostatitis

Retrograde ejaculation
The semen, which would normally be ejaculated via the urethra, is redirected to the urinary bladder. Learn more at: www.fertilitypedia.org/therapy/diag/retrograde-ejaculation

Sperm autoantibodies
Antibodies that bind to sperm, inhibiting their movement, stopping recognition and entry into the egg. Learn more at: www.fertilitypedia.org/therapy/diag/sperm-autoantibodies

Teratospermia
Teratospermia is a condition characterized by the presence of sperm with abnormal morphology that affects fertility in males. Learn more at: www.fertilitypedia.org/therapy/diag/teratospermia

Testicular torsion
Emergency medical condition occurring when the spermatic cord twists and cuts off the testicle’s blood supply. Learn more at: www.fertilitypedia.org/therapy/diag/testicular-torsion
Thyroid disorders
A medical condition impairing the function of the thyroid.
Learn more at: www.fertilitypedia.org/therapy/diag/thyroid-disorders

Turner syndrome
Turner syndrome is a genetic disorder in which a female is partly or completely missing one X chromosome that results in ovarian dysgenesis.
Learn more at: www.fertilitypedia.org/therapy/diag/turner-syndrome

Undescended testes
In the case of cryptorchidism one or both testes are absent from the scrotum. It is the most common etiologic factor of azoospermy in the adult.
Learn more at: www.fertilitypedia.org/therapy/diag/undescended-testes

Y-chromosome deletions
A family of genetic disorders caused by missing gene(s) in the Y chromosome.
Learn more at: www.fertilitypedia.org/therapy/diag/y-chromosome-deletions

Reproductive functions

Ovulation
The release of egg(s) from the ovaries.
Learn more at: www.fertilitypedia.org/edu/reproductive-functions/ovulation

Organs

Pituitary gland
An endocrine gland, about the size of a pea, whose secretions control the other endocrine glands and influence growth, metabolism, and maturation.
Learn more at: www.fertilitypedia.org/edu/organs/pituitary-gland

Gallery

Pic. 2: Reference ranges for the blood content of follicle-stimulating hormone levels during the menstrual cycle
The time scale starts with the beginning (or "onset") of (last) menstrual period, given as day number.

Pic
35.5 kDa glycoprotein heterodimer, consisting of two polypeptide units, alpha and beta.
<table>
<thead>
<tr>
<th>Follicle-stimulating hormone</th>
<th>Lower limit</th>
<th>Upper limit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepubertal</td>
<td>&lt;1</td>
<td>3</td>
<td>IU/L</td>
</tr>
<tr>
<td>Adult male</td>
<td>1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Adult female (follicular</td>
<td>1</td>
<td>11</td>
<td>IU/L</td>
</tr>
<tr>
<td>and luteal phase)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult female (ovulation)</td>
<td>5</td>
<td>15</td>
<td>IU/L</td>
</tr>
<tr>
<td>Post-menopausal female</td>
<td>30</td>
<td>118</td>
<td>IU/L</td>
</tr>
</tbody>
</table>

**Sources**

“Anatomy & Physiology” [https://cnx.org/content/FPtK1zmh@7.31/mg9jPatU@3/Fertilization]” — sourced from OpenStax College licensed under CC BY 4.0 Download for free at http://cnx.org/content/col11496/latest/

“Follicle-stimulating hormone” [https://en.wikipedia.org/wiki/Follicle-stimulating_hormone]” — sourced from Wikipedia licensed under CC BY-SA 3.0

“Follicle-stimulating hormone” [https://www.boundless.com/definition/follicle-stimulating-hormone/]” — sourced from Boundless licensed under CC BY-SA 4.0

“Follicle-stimulating hormone during menstrual cycle” [https://commons.wikimedia.org/wiki/File:Follicle-stimulating_hormone_(FSH)_duringメンスナル_cycle.png]” — by Häggström licensed under CC0 1.0

“Follitropine” [https://commons.wikimedia.org/wiki/File:Follitropine.gif]” — by Rombik&;#153 licensed under CC0 1.0

“Follicle-stimulating hormone” [uploads/84/3a32/1b1/84ca321b15c3342986f50cebc7abb830245c3b42.png]” — by Petráková, created for Fertilitpedia.org licensed under CC BY-SA 4.0