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Spermatogenesis : correlation in Ayurveda

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ABSTRACT

The spermatogenesis is the important stage of male developmental biology. The spermatogenesis is a complex process that involves multiplication, development & maturation of germ cells into male gamete. The *Shukra Dhatu* is the seventh *Dhatu* of body which is has no *Dhatu-Mala*. Ayurveda has praised *Shukra* for its functions like *Bala, Priti, Prajotpadana* etc. Only a viable and quality *Shukra Dhatu* is capable of reproduction. Any defects in the *Shukra* formation will eventually affect its normal functions. The understanding of spermatogenesis is a prerequisite for diagnosing and treating male infertility. An attempt has been made in the present paper to understand the process of spermatogenesis in Ayurveda in relation to *Shukra Dhatu Utpatti* and its *Karya* (functions).

Key words: *Spermatogenesis, Male Sex Hormones, Shukrotpatti, Shukra.*

INTRODUCTION

The reproductive functions of the male can be divided into three major subdivisions.[1]

1. Spermatogenesis
2. Performance of the male sexual act and
3. Regulation of male reproductive function by the various hormones.

Associated with these reproductive function are the effects of male sex hormones on the,

- Accessory sexual organs
- Cellular metabolism
- Growth and other functions of body

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Spermatogenesis

Spermatogenesis is the process of formation of mature sperm from the primordial germ follicle in the male. The primordial germ cells migrate into the testes and become immature germ cells called spermatogonia. These spermatogonia lie in the seminiferous tubules of testes. The formation of spermatogonia occurs during the formation of embryo. At puberty, these spermatogonia begin to undergo mitotic division, proliferate and differentiate through different stages of development to form sperm.[2]

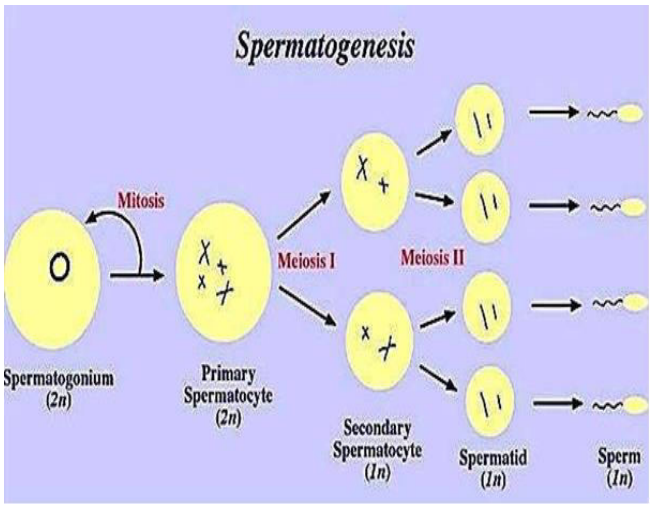

Figure 1: The steps of spermatogenesis

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The Spermatogenesis,

- Begins at an average age of 13 years and continues throughout the most of the remainder of life and decreases markedly in the old age.
- It occurs during the active sexual life
- It occurs in the seminiferous tubules of testes as a result of pituitary gonadotropic hormones.

The initiation of onset of puberty (13 years) has long been a mystery. But it has now been determined that during childhood the hypothalamus simply does not secrete significant amounts of GnRH.

The steps of spermatogenesis are grouped as,[3]

a) The pre-spermatogoniogenesis - which occurs in fetus and infants, it is formation of spermatogonia from germ cells.

b) The maturation of spermatocytes - which occurs after the onset of puberty, it is the formation of spermatids from spermatogonia.

c) The spermiogenesis - occurs in adults, it is formation of mature sperm from spermatids.

The spermatogonia are the precursor cells to sperms. The formation of spermatogonia (male gametes) from primary germ cells is called as pre-spermatogoniogenesis. The primordial germ cells are common to all type of tissue production. They are the cells which give rise to all other tissues in body. So the case with the male gamete cells.

The spermatogonia are the precursors of sperm and they are produced in childhood until male reaches puberty but not expressed themselves to be able to continue to form the mature spermuntil the arrival of puberty. The spermatogonia represent the reserve of sperms. The formation of spermatogonia from germ cells is called prespermatogenesis. The prespermatogenesis is the preparatory period for spermatogenesis. The same is the case with testosterone hormone. The testosterone is present in male (dominant in amount compared to females) since birth and performs its somatic functions, the GnRH will stimulate the testosterone only after puberty for its sexual functions. This means they (spermatogonia and testosterone) are present but not expressed.

The maturation of spermatocytes

The spermatogonia migrate among sertoli cells (in the seminiferous tubules) and becomes progressively modified and enlarged to form primary spermatocytes. This takes total of 25 days.

- Each of primary spermatocytes undergoes meiotic division to form secondary spermatocytes which takes 9 days in total.
- Secondary spermatocytes divide to form spermatids which take 19 days.

The spermatids will eventually modified to become spermatozoa (sperm) which takes 21 days. Each spermatid is divided into two spermatozoa by meiosis hence the 46 chromosomes of each spermatocyte are divided into 23 to both (first and second) the spermatozoa. This means half of the genetic characteristics of future foetus are stored in spermatozoa.

Hormonal factors that stimulate spermatogenesis[4]

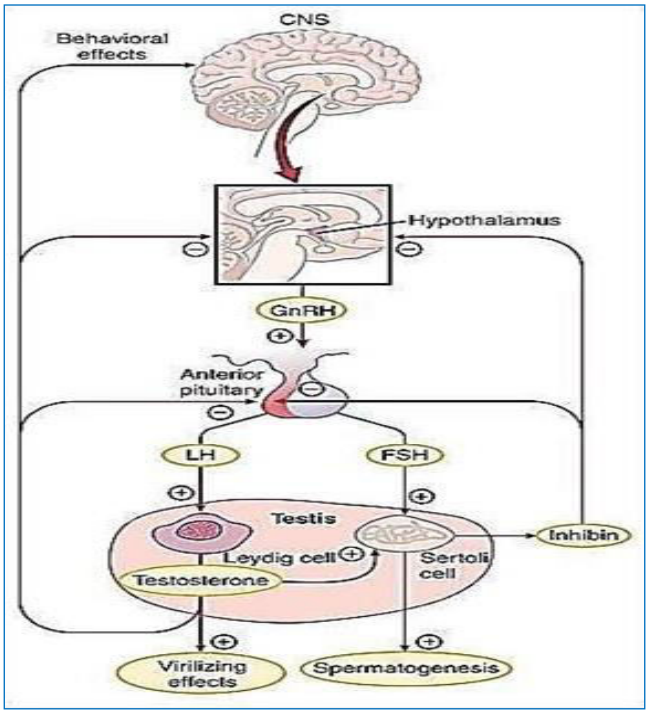

Figure 2:The feedback regulation of hypothalamic-pituitary-testicular axis in males

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Several hormones play essential role in the stimulation of spermatogenesis. They are as follows.

1. **Testosterone**
   - It is secreted by the leydig cells (also called as interstitial cells) of testis
   - It is essential for the growth and division of testicular germinal cells
2. **LH (Luteinizing Hormone)**
   - It is secreted by anterior pituitary gland
   - It stimulates the leydig cells to secrete testosterone
3. **FSH (Follicle Stimulating Hormone)**
   - It is also secreted by anterior pituitary gland
   - It stimulates sertoli cells
   - Without the stimulation of FSH, conversion of spermatid to sperm will not occur
4. **GH (Growth Hormone)**
   - **It promotes early division of spermatogonia themselves**
   - In its absence, spermatogenesis is severely deficient causing infertility.
5. **Estrogens**
   - It is formed from testosterone from sertoli cells when they are stimulated by FSH.
   - Their role in spermatogenesis is not exactly known, probably essential in spermatogenesis.

The hormonal stimulation can be grouped as follows,

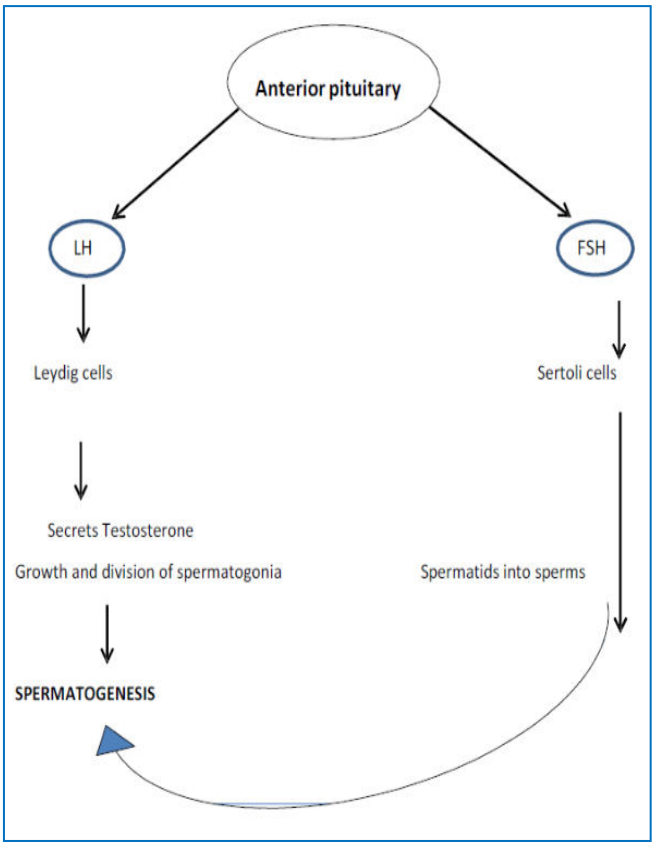
a) Extra testicular hormonal stimulation

b) Intra testicular hormonal stimulation

1. Extra testicular hormonal stimulation

The stimulation for the production of testosterone from the hormones of master gland is told under the heading of extra testicular hormonal stimulation. The major control of sexual function begins with release of GnRH from hypothalamus. This hormone in turn stimulates the anterior pituitary to secrete two other hormones LH and FSH.

Flow Chart 1: Extra testicular hormonal stimulation



- LH is the primary stimulus for the secretion of testosterone
- FSH mainly stimulates the spermatogenesis

The testosterone is produced by the interstitial cells of leydig in testes under the stimulation of LH.

2. Intra testicular hormonal stimulation

The stimulation for the production of semen (which contain sperms) by the testosterone secreted in the testes is called intra testicular hormonal stimulation.

The chief target organ of testosterone hormone is prostatic cells of prostate gland. This gland also contributes more to the fluid constitution of ejaculated semen. From the testes, secreted testosterone enters prostate gland (cells) and there it induces the DNA and RNA transcription for the production of proteins (protein anabolism).

At this point, the testosterone has two fates.

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- The part of testosterone becomes fixed to target tissue (prostate) and later utilized and excreted when in need
- The remaining part of testosterone enters circulation stays for hours and degraded and excreted by urine if not needed.

Androgens

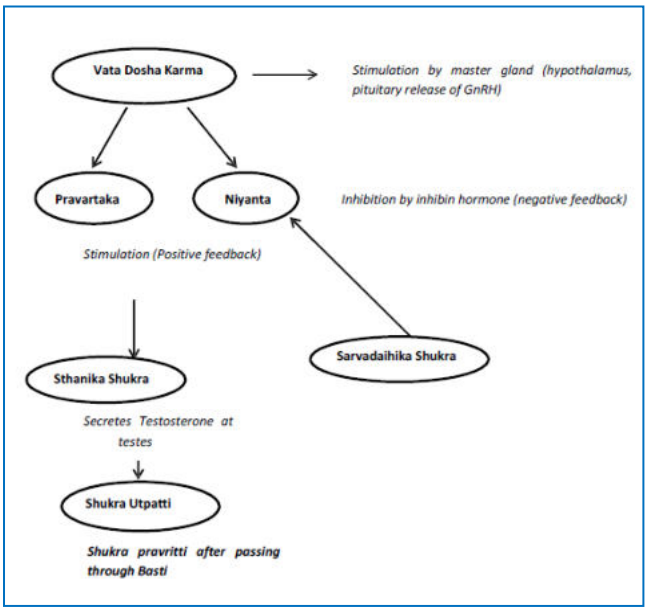
The testes secrets several male sex hormones, which are collectively called androgens, including testosterone, dihydrotestosterone and androstenedione. The term androgen means any steroid hormone that has masculinizing effects, mainly testosterone.

Testosterone is considered to the primary testicular hormones and found much more abundant than other two. Dihydrotestosterone is the active form of testosterone itself.

The testosterone constitutes about 20% of mass adult testes. The leydig cells are almost non- existent in the testes during childhood secrets no testosterone, but they are numerous in the new born male infant for the first few months of life and in adult male after puberty.

DISCUSSION

Spermatogenesis vis a vis *shukrotpatti*



Flow Chart 2: Spermatogenesis vis a vis *Shukra Utpatti* and *Pravritti*.

The *Shukra Dhatu* in Ayurveda cannot be equated with single entity of male sexual functions/structures in contemporary science. The semen and its other contents, sperm and androgens (97% of functional androgen is testosterone) together can be equated to *Shukra Dhatu* in Ayurveda based on the functions of *shukra dhatu* in *sharira.*

These are correlated to *Shukra* by their functions as follows,

- Testosterone - the stimulator of production and ejaculation of semen
- Semen - the fluid which is an alkaline (*Soumya Dhatu*) nutrient fluid containing sperm ejaculated during the male sexual act.
- Sperm - the functional unit of semen for reproduction.

Semen is *Dhatu Rupi Dravya* and mature sperm is the *Bija Rupi Shukra* in Ayurveda. This is explained in Ayurveda by considering the concept of *Parinama* i.e. *Kaala,*[5] They become *Vyaktha* (expressed) at right time for their expression (puberty). The reason for the *Vyaktata* (expression) of these *Bhavas* at later life is *"Manushya Swabhava" (nature of human being).*[6] The same has been determined by contemporary science the reason is 'simply' means *Swabhava* (nature).

These primordial germ cells are correlated to outcome of combination of *Shukra-Shonita* along with *Tridosha* since it is said in Ayurveda both the *Bija (Shukra-Shonita)* and *Tridosha* are the *Deha Sambhava Hetus* (cause for the origin of body*).* The primordial germ cells are the *Deha Sambhava Hetu* (cause for the origin of body*),* meaning they give rise to *Sambhava* (origin) of all *Dhatus* in *Sharira* including *Shukra Dhatu* of progeny.

This explanation matches the Ayurveda explanation of importance of *Vaya Parinama* in *Shukra Pradurbhava* with the simile given of *Pushpa Mukula Gandha Pradurbhava* at right *Kala*.[7]

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The maturation of spermatocytes

The spermatogonia migrate among sertoli cells (in the seminiferous tubules) and becomes progressively modified and enlarged to form primary spermatocytes. This takes total of 25 days.

This matches with the explanation of *Shukra Utpatthi* after the *Baala Avastha* (in *Youvana*) since the maturation of spermatocytes into spermatids begins after the puberty. The one of duration for *Shukra Utpatthi* is told to be one month which is almost equal to the above said duration for maturation into spermatocytes (25 days).

The above said progressive mitotic and meiotic division and multiplication of spermatocytes to form spermatids is correlated to *Paramanu Vibhajana* by *Vayu Karma Swabhava*.

This explanation of storage genetic characteristics in the chromosomes matches with the Ayurveda explanation of *Kshetrajna, Vedayita* etc. and *Shukra* is for *Bijartha*.[8]

Hence the testosterone at prostate gland is not free/circulating which can be correlated to

Sthanika Shukra and circulating testosterone is correlated to *Sarvadaihika Shukra*.

- The testosterone at the level of prostate influences release of semen.
- Circulating testosterone diffused into blood from the prostate gland after entering circulation has its effects on its target tissues (muscle, bone, male sex organs and accessory sex organs).

Androgens include male sex hormones produced elsewhere in the body besides testes. This matches with the Ayurveda explanation of *Shukra* present in *Sarva Sharira.*[9]

The *Shukra Dhatu* in Ayurveda includes all the male sex hormones since all proof them have similar function. The evidence that androgens are also secreted outside the testis matches the description of *Sarvadaihika Shukra.*

Testosterone

At these both times (new born and adult life) great quantities of testosterone is secreted. This uncertainty in the great quantities of testosterone is attributed to *Kala Parinama* in Ayurveda for the *Pradurbhava* of *Shukra.*

Functions of testosterone compared with functions of *Shukra Dhatu*

In general testosterone is responsible for the characteristics of the masculine body. This means that the *Shukra Dhatu* is represents all the *Pitruja Bhavas* of *Sharira*[10] since the *Pitruja Bhavas* are the *Bhavas* having *Sthira Guna* responsible for the more masculinity in males.

During foetal development,

1. The testosterone is responsible for the development of male body characteristics, including formation of penis and scrotum as well as prostate gland, seminal vesicles and male genital ducts.
2. The stimulus for the descent of testes is testosterone.

The male body characteristics by the *Shukra Bija Guna* are considered as testosterone function. The formation of male sex organs is also decided by *Shukra Bahulyata* (testosterone).

The descent of testes is by *Shukra Dhatu* along with *Vayu Karma*. Since it is only the testosterone can form testes and make it descent which is specific to males.

During adult life,

Development of adult primary and secondary sexual characteristics Testosterone in adults causes,

- Growth of hair over the penis, face and chest.
- Typical adult masculine voice
- Increases thickness of skin
- Protein formation and muscle development
- Increases bone matrix
- Increases BMR: It increases BMR by its protein anabolism.

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- Increases RBC

Testosterone is not related to RBC and does not have a direct effect on erythropoiesis but indirectly effects RBC production by increasing BMR.

- The blood and extra cellular fluid volume of the male after puberty increases by 5 to 10%

The above said functions of testosterone are as a result of protein anabolism. Hence the protein anabolism in Ayurveda can be considered as function of *Shukra* since *Shukra Dhatu* is said to be responsible for *Dehabala* and *Upachaya.*[11] *Shukra* is the *Apa* and *Prithvi Guna* dominant *Dhatu,* hence it can increase the similar *Guna Dhatu*, so only testosterone does increase in ECF volume.

Justification for correlating testosterone hormone to *Shukra*

Most effects of testosterone results from increase in protein formation at the target cells (prostate gland to be the most affected).

Testosterone enters prostatic cells within few minutes of secretion, converted to dihydroanderostenedione by the enzyme '5α reductase'. This dihydroanderostenedione in turn binds with protein and induces DNA-RNA transcription which induces cellular protein metabolism.

Testosterone stimulates protein production not only in the target cells but virtually everywhere in the body responsible for both primary and secondary sexual characteristics of body.

This means that,

- Testosterone is responsible for overall protein metabolism as Protein metabolism at target cells (prostate) as well as everywhere in the body are performed by testosterone.

The *Shukra Dhatu* of *Sharira* gives *Dehabala* and *Upachaya* which is parallel with protein metabolism (as it is the anabolic effect). This *Bala* and *Uapachaya* are done at its own specific target *Dhatu (Shukravaha Srotas Karma*) as well as *Sarva Sharira.*

Spermatogenesis begins at an average age of 13 years continuing throughout most of the remainder of life but decreasing markedly in old age.

Dr. Alvin M. Matsumoto, in his review of the fundamental scientific aspects of androgen deficiency in aging men, describes the loss of serum testosterone as an age-related physiologic change - as men grows older, their testosterone levels decline. This decline in testosterone can be attributed to diminished testicular production of testosterone and reduced hypothalamic secretion of gonadotropin - releasing hormone, which results in inadequate luteinizing hormone secretion by the pituitary gland.[12]

Hence from the above, the relation of *Shukra Dhatu* with age is considered. The *Shukra Dhatu* diminishes as the age advances. The *Dosha* and *Dhatus* are under the continuous influence of *Vaya.* The *Vata Dosha Pradhanyata* of *Vriddhavastha* causes *Shukra Dhatu Kshinata.*

Correlating prostate gland to *Basti* in Ayurveda

The prostate gland is the main target tissue influenced by testosterone; also the semen has most of its fluid contents as secretions from prostate gland. The sperm after its production from seminiferous tubule enters prostate. It is only after reaching prostate gland it is ejaculated out. Also anatomically prostate gland is related to bladder only. Thus this prostate gland in Ayurveda can be considered as *Basti,*[13] and in the reference it is told that the *Sthana Vichyuta Shukra* (sperm from epididymis) ejaculated out through penis only after passing through the tubules, reaching the prostate.

Correlation of functions of FSH and LH

It is very important to make a note on 'the LH involves many steps to produce sperm but the FSH stimulates directly on the spermatid to produce sperms.'

Hence LH by its stimulatory pathway resembles the *Krama Utpatthi* of *Shukra* from *Rasa Dhatu* (by *Kedarikulya Nyaya*). Because the LH mainly involves the conversion right from spermatogonia to mature sperm which is a lengthy process.

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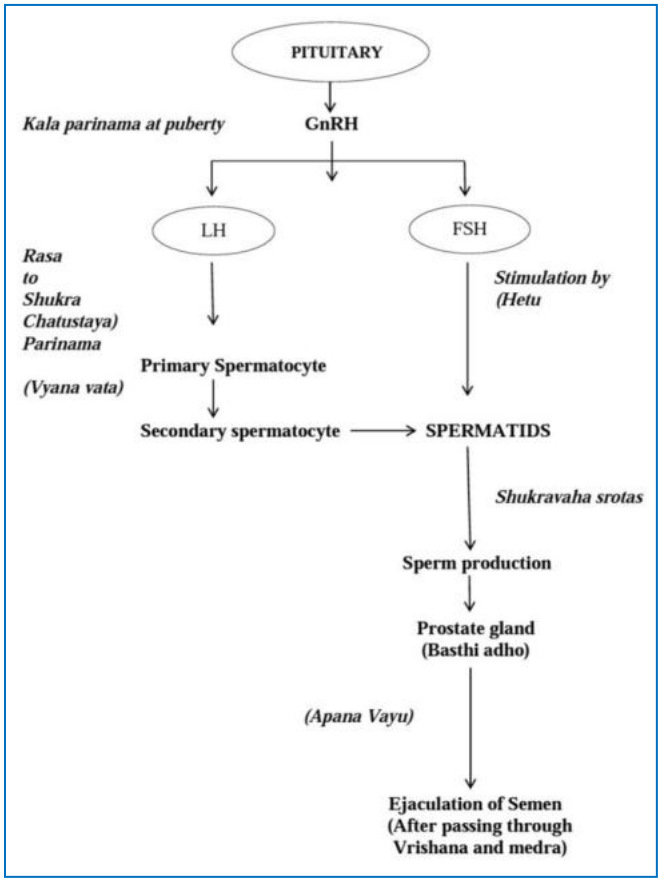
The above description of hormonal stimulation is depicted in the below flow diagram[13]



Flow Chart 3: Hormonal stimulation

1. The extra testicular hormonal stimulation is correlated to *Vata Dosha Karma* since *Vata* is the regulator of all functions of body (*Tantra Yantra Dhara*)

The functions of hypothalamus, pituitary gland, LH and FSH are all compared to *Vata Dosha Karma* since they stimulate the production of hormone testosterone. *Vata Dosha* is the regulator of all the *Doshas* and *Dhatus* in *Sharira.*

2. The intra testicular hormonal stimulation by testosterone is correlated to *Shukra Dhatu Karma* for the production and ejaculation of semen (*Utpatti* and *Pravritti* of *Dhaturupi Shukra)*

CONCLUSION

The formation of spermatogonium from primordial germ cells correlates with the formation of *Shukra Dhatu* in the progeny by the combination of, *Shukra Shonita* and *Tridosha,* since both them are *Dehasambhava Hetu*. The maturation of spermatocytes under the influence of increased Testosterone beginning at puberty is correlated with *Shukrapradurbhava* after the completion of *Balavastha* under the influence of *Kala Parinama.*

The hormonal mechanism involved in spermatogenesis are concluded as follows;

- Extra Testicular hormonal stimulation for secretion of Testosterone is correlated with *Vata Dosha Prakrita Karma* in the *Shukra Dhatu Utpatti* from *Rasa Dhatu.*
- Intra Testicular hormonal stimulation for the production of sperm and ejaculation of semen is correlated with *Sthanika Shukra Dhatu Utpatti* and *Pravritti* by the effect of *Shukra Pravritti Hetus.*

Testosterone harmone by its functions is correlated with *Shukra Dhatu. Shukravaha Srotas* can be correlated with reproductive system. *Shukra* is present in children but is not in functional state and becomes functional only at right time (by *Kala Parinama*) i.e,. puberty.

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