

Microgravity and Infertility

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ABSTRACT

It was observed that swim rate of sperm changes in microgravity. Sperm swim with higher velocity in microgravity. The fertilization might be affected by this mobility changes in sperm and this led to reduction in sperm motility under microgravity. Follicle-Stimulating Hormone (FSH) that is responsible for ovulation in women by triggering egg maturity and stimulating sperm production in men can be damaged by microgravity. Therefore, ovulations and triggering of egg maturity and production of sperm may not take place. Higher acidity of outer vagina due to fluid distribution at the upper part of the body might kill the sperm or reduce sperm counts. Microgravity environment reduced the thickening of the endometrium to the extent that eggs cannot be planted (cause non-implantations).

KEYWORDS: *Microgravity, Follicle-Stimulating Hormone (FSH), Sperm, Endometrium*

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1. INTRODUCTION

As the space program is becoming more interesting as space age progresses, there is need to pursue research that can determine the possibility of humans to pursue normal life in space including performing reproductive function. The effects of the environmental factors in space that are different from those on earth has being studied. These include the effects of gravity, solar rays, ultraviolet rays, electromagnetic waves, temperature and radioisotopes. The concern has being with the effect of a long-term stay in space on the human body, and examination of the effect of a microgravity environment on human sperm motility has being researched upon (Takahitoet al., 2005).

Changes in the gravitational field have significant effects on the development of plants and animals. Therefore, the potential effect of a microgravity (μ G) environment on reproduction has been a major biological theme in the age of space exploration. So far, several experiments on reproduction in such environments have been reported using sea urchins, fish, amphibians and birds, and the fertilization rates were similar to those found in controls at normal gravity (1G).

However, unlike the other group studied to date, mammalian reproduction is complicated and highly specialized.

It was discovered that the durations (short and long) of staying in the microgravity environment have different effects on mammalian reproductive system. A male rat was mated with a female rat 5 days after returning from a 2.5 to 3 months flight in the biosatellite Kosmos-1129. The growth of the neonates was impaired, and the mortality was reportedly high. In 1996, a female rat was placed in the space shuttle from days 9–20 of gestation and was reported to have offspring with normal growth.

Studies on rats have shown that μ G affected reproduction: there were decreased total sperm numbers, increase in sperm abnormalities, and reduced testicular weights during space flight. In the STS-80 space shuttle mission, mouse 2-cell embryos were collected on the ground, launched into space and cultured for four days in μ G. The control embryos on Earth developed to normal blastocysts, but in the space flight group, none of the embryos showed any sign of development, and all degenerated.

Brandon, (2009) stated that the potential effects of low gravity would be pronounced in mammals, whose embryonic development is more complicated and sensitive than other animals. According to Brandon, to test these effects, the researchers artificially fertilized mouse eggs with sperm that

had been stored inside a three-dimensional clinostat, a machine that mimics weightlessness by rotating objects in such a way that the effects of gravity are spread in every direction. Fertilization took place normally, suggesting that microgravity had not harmed the sperm. But as the embryos continued to develop inside the clinostat, many developed problems. The cells had trouble dividing and maturing i.e. cellular processes are affected by low-gravity environment, showing as abnormal cell division.

There are some researches done on embryonic development of mice and rats in microgravity, both impregnated females sent to orbit and later recovered (mostly onboard Space Shuttle) and even more frequently by using 3D clinostat to stimulate microgravity via continuous three-dimensional rotation. Reduced number of successful full-term pregnancies was observed for females exposed to microgravity during early pregnancy, while fewer abnormal pregnancies for those exposed later. Findings suggest that embryonic stem cells have problems developing normally under microgravity conditions during early pregnancy and result in abnormal fetal development and terminated pregnancy.

A more reliable experiment was done on the Cosmos 1129 mission in 1979, when mature male and female rats were sent into orbit and then allowed to intermingle in a common breeding chamber. However, none of the females gave birth, although post flight examinations revealed that ovulation had occurred. Two of the females were reported to have achieved pregnancy, but the embryos appear to have been desorbed. Although this experiment did not examine whether fertilization or pre-implantation development occurred normally, this raised the important question of whether mammalian reproduction is indeed possible in space. However, further such experiments have not been performed so far because of technical difficulties in using live animals. Mammalian reproduction is very sensitive to environmental factors. For example, with mice and rats, if the breeding room is changed, the estrous cycle is altered, the number of oocytes ovulated is reduced and mating can fail. If mice were to be taken into space, they would be exposed to strong vibrations and hypergravity during the launch, and then suddenly exposed to the additional stress of μG conditions. In these situations, it is highly unlikely that the mice would copulate during the flight period. Actually, in the Cosmos 1129 mission, there were no pregnancies even among the ground-based 1G controls. Oocytes do not have enough resources to support full term development, so after fertilization, the embryo needs to implant in the uterus and to be supplied from the mother via the placenta (Sakayaet *al.*, 2009).

No vertebrates have been raised from conception to sexual maturity in absence of gravity. No birds or reptiles have bred on orbits, although fertilized chicken and mammal are employed most frequently for space research. Analysis that was done on Rat within two weeks, on space shuttle, was discovered that the rat neonates go through critical development period, during which rapid neural (nervous system which consist of brain, spinal cord, smooth muscles, heart and glands) and motor (conveying information to the brain from the central nervous system) development occurred. On several occasions, however, pregnant rats flown in space gave birth to normal neonates after flight. It was

observed that during post-flight delivery, flight dams are twice as many of abdominal contractions as the ground controls, suggesting that more extended exposure to spaceflight could have a detrimental effect on pregnancy at the birthing process (Gilles, 2007).

Based on animal experiment in the spaceflight, it was observed by the researchers that fetal development is affected in space, and that bones, muscles (including heart muscles), neurology (study of structure, function, diseases and disorders of the central nervous system) will simply not develop properly without Earth gravity. Also, it was known that human hormones and even sperm motility (movement of sperm) are affected by lack of gravity.

This work is based on intense review of some previous work on microgravity infertility, and human reproduction in microgravity environment as secondary data.

2. CONCEPTUAL FRAME WORK

According to Sarah (2014), spaceflight may make astronauts infertile; scientist fear, and could hinder plan for a long-term mission to Mars. Animals' experiments have shown that both male and female reproduction organs are affected by zero gravity. Laura (2006), warn of the danger associated with conceiving in space. On cautionary note, men and women in their childbearing years will need to be careful not to conceive a child while in space, since it may be dangerous to the mother and baby.

Radiation is a serious problem; even in the Earth orbit where the magnetic field protects somewhat. In space, it is also likely that radiation will damage the ovaries of female astronauts and the sperm production of men; and cosmic radiation may also be harming fertility. Previous Russian studies reviewed that when male and female rats were sent into space in 1979, they did not mate at all. Another study found that when male rodents were placed in stimulated zero gravity conditions they could no longer produce sperm.

2.1. Microgravity Effects on Sperm

Clement (year), in his book: Fundamental of Space Medicine stated that "Fertilization might also be affected by mobility changes in sperm". In fact Bull sperm swim with higher velocity in microgravity. Tash Joseph (2012) stated that, "Space also has challenging or intriguing or disturbing impact on sperm; and that sperm actually swims faster in space, possibly because the tail of the sperm can grow longer in zero gravity. It can be observed that this fast movement of sperm in microgravity environment might affect the sperm fertility in the following ways:

- The sperm might get warmer than normal temperature for fertilization to occur.
- It might have higher impact on the female egg than normal thereby creating temperature gradient in the egg, i.e. generating heat, because the temperature gradient can cause increase in the temperature of the egg.
- The high velocity of the sperm coupled with lack of lubrication of vaginal wall under microgravity environment can cause the generations of frictional force between the vaginal and flowing sperm, which might generate heat that will destroy the sperm.
- Hoping also that the sperm is not watery too? At that high velocity.

In Takahito *et al.*, 2005, it was made to known that concerning sperm motility there has been only a single report that the mobility and linear movement of bovine (cattle) sperm were increased significantly in a μG environment. Their findings with clinostat methods suggest that sperm motility is reduced under μG . **Takahito (2005)**, defined motility as the percentage of motile sperm among the total sperm. The percentage of sperms that is able to make to the end decreases. It can be observed that some of the sperm died on their way swimming through the virginal. This might as a result of acidity of the virginal at microgravity, lack of lubrication of virginal because of the lack of secretion of fluid from the virginal for ease of insertion. Frictional force is generated between high speed sperm and un-lubricated virginal wall. The alteration in gravity that causes changes in mammalian male and female reproductive systems is in a rather complex manner.

Due to damage in the sperm production, if possible that fertilization of eggs takes place and develop to birth, there are possibilities that offspring will have growth retardation and abnormalities in some part of their system. *Touet al.*, (2002); Gilles (2011); Gilles and Slenzka (2006) explained that, male rats mated 5-days after flight to non-space experience females produced offspring with growth retardation and many abnormalities such as hydrocephaly (an abnormal condition in which cerebrospinal fluid collects in the ventricles of the brain-one of the four connected brain cavities) in infants which can cause abnormal rapid growth of the head and bulging fontanelles-membranous gap between the bones of the cranium-braincase, brainpan - the part of the skull that encloses the brain in an infant or fetus and small face, out of place and kidneys, and enlargement of the bladder. Mating two and half to three months after the spaceflight, produced healthy and viable offspring. Even reduction in male rats testis weight and testosterone was found and this not only in rats but also discovered that reduction in the testosterone was reported to be found in humans during flight and post flight.

According to **Tash (year)**, of the Department of Molecular and Integrative Physiology at University of Kansas reported at a conference in Hawaii that there was concern that astronauts could experience the same effects of inability to produce sperm and that space flight can disrupt important chemical reactions. Metabolism comprises all chemical reactions that occur in the human body. It includes catabolism, or the breakdown of chemical substances; and anabolism, or the building of chemical substances. Examples include respiration and digestion, both of which take in nutrients and convert them to useful energy. In the related process of excretion, the body rids itself of metabolic waste products, which would otherwise be lethal. Chemical reactions must happen in the body to allow reproduction.

Tash (year), discovered that many of the system that are shutting down during spaceflight syndrome are linked to the hormone oestrogen. This is a hormonal network that is secreted to control both the male and female reproductive systems and assist in the growth and development of the fetus and the birthing process. Maria(2012), quoted Maria Masini that "the sperm cell number was significantly reduced in space flight mouse (rodents) epididymis – convoluted tubule in each testis, carries sperm to vas deferens.

Indicating that space environment may lead to degenerative changes in seminiferous tubules. These degenerative effects could be due to not just radiation damage, but to the lack of gravity as well. The natural external location of testes provides a cooler environment in the presence of gravity and convection. Without gravity the testes would sit closer to the body and without any air convection they would be at a higher temperature, which could impair sperm production in mammals.

The Mars one mission currently scheduled to land its first crew on the Mars planet in 2025, but volunteers have been warned that conception may not be possible in reduced gravity and fetus born on Mars may not develop properly. It was also stated that: Astronauts travelling to Mars will be exposed to high levels of radiation, not only because of the length of the mission; between six to eight months, but also because most of the journey is outside Earth's protective magnetic fields.

Roncaet *al.*, (2014) stated that "Spermatogenesis in men may be impaired beyond effects of radiation exposure. A 120-day Russians bed rest study found that sperm collected after 50-60 days and 100 days exhibited a reduction in live spermatozoa showing active mobility and increase in the percentage of morphologically/structurally altered spermatozoa.

Several hypothalamic transmitters are altered by real or stimulated spaceflight. Alteration in hypothalamic pituitary gland and hypothalamic pituitary adrenal axes have been reported following space flight.

The following effects of microgravity can impair spermatogenesis and result into male infertility

- Microgravity can affect integrity of specialized cell across the body.
- Microgravity also seems to disturb the anti-oxidant defense system in sertoli cells.
- Lactate concentration slightly in significantly manner decreased in zero gravity compared to control valves.
- Microgravity also increased the level of oxidative stress in sertoli cells.

2.2. Microgravity and Women Infertilities

Meleshkoet *al.*, (1994) state that, many women experience some retrograde menstruation that at Earth's gravity is usually confined to the pelvis. The retrograde menstrual condition/flow can result into infertility even at Earth's gravity. However, in microgravity there is concern that the level of the retrograde menstrual flow might be increased and that instead of being confined to pelvis, it would disperse throughout the abdominal cavity. These effects of microgravity environment on menstrual flow can intensely or severely increase infertility.

2.2.1. Sperm Cannot Survive in an Acidic Environment

Since fluid are concentrated in body's chest and head in microgravity environment there are limited amount of flow of fluid at the lower parts of the body. So, there will be limited amount of alkaline fluid that can drop by the Bartholin's gland. The Bartholin's glands are greater vestibular glands that is a pair of glands that open at the junctions of the vagina and the external genitalia (vulva). Their secretions lubricate the vulva and so assist penetration

by the penis during coitus. The lesser vestibular glands, around the vaginal opening, perform the same function to the outer vaginal via ducts. This alkaline fluid helps to counteract the acidity of the outer vagina which then allows sperm to survive). It was assumed in this paper that all fluids were affected. The possibility of not having all the acidity of outer vagina neutralized might kill the sperm or reduce sperm counts. The glands are not meant to lubricate vaginal only but also to neutralized the acidic content of the vaginal. Since there are no gravity to pull down the fluid (gland) for proper secretion (secretion need gravity to occur) the vaginal is concentrated with acid. This acidity will kill the sperm.

Apart from the acidic content, penis penetration will be hard; because the vaginal is not lubricated therefore frictional force will be developed. The development of frictional force will result to heat generation both in the penis and vaginal. The hallow open field will be warmer than normal creating temperature gradient. Also, the flowing path (urethra) of the sperm will become warmer. The sperm will encounter temperature at least twice when:

- the sperm is flowing through the warmed urethra
- the sperm enters warmed vagina

These will increase the sperm temperature. In fact, couple with abnormal swimming of the sperm, sperm temperature, lack of lubrication, and acidic concentration in the vagina will find it difficult for sperm to survive within the vagina let alone fertilizing eggs. Temperature alone can make sperm watery and reduce the sperm count. The possibility that the heat generated within the vagina can produce radiation that can flow into the ovary and equally affects the egg negatively.

2.2.2. Fertilized Egg Cannot be Planted in a Weak Uterus

The uterus is a hollow, muscular organ where a fertilized egg (ovum) will implant itself and grow into fetus. The uterus lies in the pelvic cavity between the bladder and the bowel and above the vagina. The uterus innermost layer called the endometrium is where the egg is implanted. During ovulations, this thickens for implantation. The following might cause non-implantations:

- The pelvis' muscles and bone are already weakened under microgravity environment.
- The muscular organ (uterus) also weakens and shrinks under microgravity environment.
- Vagina muscles are weak under microgravity environment.
- Life from blood not released into the vaginal muscles, pelvic muscles and uterus muscles due to malfunction of muscular contraction rate in microgravity environment.

The above-mentioned assumptions may cause non-thickness of the endometrium and implantations of egg will not be possible.

Follicle-Stimulating Hormone (FSH) that is responsible for ovulation in women by triggering egg maturity and stimulating sperm production in men can be damaged by microgravity. Therefore, ovulations and triggering of egg maturity will not take place. Since brain will be affected due to improper fluid re-distribution, the hormone secreted will not be fully received by the brain and the brain will not be

able to send signals for the production of sperm. Women ovulations will also be hindered.

In addition, high level of exposure to radiation can be harmful to the creation of sperm in males. With low sperm counts, the likelihood of pregnancy in the first place is very low. But once conception occurs, the exposure of radiation to a forming fetus would kill the cells almost immediately. Therefore, even if fertilization could occur, the cells would not be able to replicate and form an actual fetus. As earlier explained that inhibition of spermatogenesis as a result of decreased testicular blood flow caused by the movement of body fluid to the head in males can affect fertilization and fetus development as well as decrease in testosterone levels under microgravity and their effects on fertilization and embryogenesis.

3. FINDINGS

That sperm actually swims faster in space, possibly because the tail of the sperm can grow longer in zero gravity. This fast movement of sperm in microgravity environment might affect the sperm fertility in the following ways.

- The sperm might get warmer than normal temperature for fertilization to occur.
- It might have higher impact on the female egg than normal thereby creating temperature gradient in the egg, i.e. generating heat, because the temperature gradient can cause increase in the temperature of the egg.
- The high velocity of the sperm coupled with lack of lubrication of virginal wall under microgravity environment can cause the generation of frictional force between the virginal and flowing sperm, which might generate heat that can destroy the sperm.

That the sperm motility reduces under μG which is the percentage of motile sperm among the total sperm. (i.e. the percentage of sperms that is able to make it to the end decreases).

That reduction in the testis weight and testosterone was found both in rats and human during flight and post flight. Without gravity the testes would sit closer to the body and without any air convection they would be at a higher temperature, which could impair sperm production in mammals.

That conception may not be possible in reduced gravity and fetus born in microgravity environment may not develop properly because astronauts will be exposed to high levels of radiation, not only because of the length of the mission, but also because most of the journey is outside Earth's protective magnetic fields.

That in microgravity there is the concern that the level of the retrograde menstrual flow might be increased and that instead of being confined to pelvis, it would disperse throughout the abdominal cavity. These effects of microgravity environment on menstrual flow can intensely or severely increase infertility.

That concentration of fluid at the upper part of the body, limits the amount of alkaline fluid that can drop by the Bartholin's gland to neutralize acidity of the vaginal and to lubricate it. Penis penetration will be hard; because the vagina is not lubricated therefore frictional force will be developed. The development of frictional force will

result to heat generation both in the penis and vagina. The infield will be warmer than normal creating temperature gradient. Also, the flowing path (urethra) of the sperm will become warmer. The sperm will encounter temperature at least twice when:

- the sperm is flowing through the warmed urethra
- the sperm enters warmed vagina

These will increase the sperm temperature. In fact, couple with abnormal swimming of the sperm, sperm temperature, lack of lubrication, and acidic concentration in the vagina will find it difficult for sperm to survive within the vagina let alone fertilizing eggs. Temperature alone can make sperm watery and reduce the sperm count. The possibility that the heat generated within the vagina can produce radiation that can flow into the ovary and equally affects the egg negatively.

- The uterus innermost layer called the endometrium is where the egg is implanted. During ovulations, this thickens for implantation. The microgravity environment reduces the thickening of the endometrium to the extent that eggs cannot be planted (cause non-implantations) because the following muscles might have been affected- pelvis, vaginal, and uterus, these are likely to affect blood flow to the vaginal to reduce the muscles contraction rate malfunctions.
- FSH that is responsible for ovulation in women by triggering egg maturity and stimulating sperm production in men can be damaged by microgravity. Therefore, ovulations and triggering of egg maturity will not take place.
- In addition, high level of exposure to radiation can be harmful to the creation of sperm in males. With low sperm counts, the likelihood of pregnancy in the first place is very low. But once conception occurs, the exposure of radiation to a forming fetus would kill the cells almost immediately. Therefore, even if fertilization could occur, the cells would not be able to replicate and form an actual fetus. As earlier explained that inhibition of spermatogenesis as a result of decreased testicular blood flow caused by the movement of body fluid to the head in males can affect fertilization and fetus development as well as decrease in testosterone levels under microgravity and their effects on fertilization and embryogenesis.

SUMMARY

In this review, it was observed that swim rate of sperm changes in microgravity. Sperm swim with higher velocity in microgravity. The fertilization might be affected by this mobility changes in sperm and this led to reduction in sperm motility under μG . FSH that is responsible for ovulation in women by triggering egg maturity and stimulating sperm production in men can be damaged by microgravity. Therefore, ovulations and triggering of egg maturity and production of sperm may not take place. Some of the sperm died on their way swimming through the vaginal, as a result of acidity of the vaginal and lack of lubrication of vaginal. Frictional force generated between high speed sperm and un-lubricated vaginal wall coupled with higher acidity of outer vagina due to fluid distribution at the upper part of the body which might kill the sperm or reduce sperm counts. The uterus innermost layer called the endometrium is where the egg is implanted. During ovulations, this thickens for

implantation. The microgravity environment reduces the thickening of the endometrium to the extent that eggs cannot be planted (cause non-implantations) because the following muscles might have been affected- pelvis, vaginal and uterus. These are likely to affect blood flow to the vagina and the muscles contraction rate malfunctions.

Conclusion

Microgravity environment will have severe adverse effects on human reproduction as it affects erection, sperm, ovulation, formation of fetus. Based on the discovery so far, no planet apart from the earth that could sustain human lives as the Earth does. Under normal earth gravity, all the components of the body are effectively working against gravity to be well compacted and strong for effective performances. Based on animal experiments, fetal development is affected by space. Bones, muscles (including heart), and neurology, will not develop properly without gravity, and that human hormones and even sperm motility are affected by lack of gravity. Therefore, microgravity environment may not be a conducive environment for effective reproduction since all the components of organ connected to reproduction system may be impaired. Therefore plan to establish colony in microgravity environment may not be easy to actualize.

RECOMMENDATION

All factors responsible for human life and reproduction in human should be greatly considered before making final adventure into microgravity environment to maintain life and reproduction.

God established the Earth for reproduction and did it in a way that all things necessary for production are within our reach including gravity environment which is the key factors for all the activities on the Earth.

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