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A REVIEW ON THE EFFECT OF CELL PHONE ELECTROMAGNETIC RADIATION ON HISTOLOGICAL TESTICLES

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ABSTRACT

***Introduction**: Cell phones have become an essential possession for individuals in today's society. Nevertheless, beneath their widespread use lies a potential hazard in the form of electromagnetic radiation. The level of radiation emitted varies, along with its impact on the human body, particularly on the reproductive system.*
***Purpose**: This research aims to consolidate findings from existing studies on the influence of cell phone electromagnetic radiation on the histological makeup of the testes.*
***Method**: A review of literature was conducted following a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) approach, utilizing the PubMed and Scopus journal publication databases. A total of 133 articles were identified through the database search, with inclusion and exclusion criteria established based on the PICOS framework. Following the screening process, six articles met the predetermined criteria and were deemed suitable for analysis.*
***Result**: The results of the study demonstrate that exposure to electromagnetic radiation led to alterations in the histological structure of the testes in experimental animals.*
***Conclusion**: In conclusion, prolonged exposure to electromagnetic radiation has an impact on the histological composition of the testes in experimental animals.*

***Keywords** : Electromagnetic Radiation, Histology, Testicles, Cell Phone*

ABSTRAK

Pendahuluan: Ponsel telah menjadi barang yang sangat penting bagi individu di masyarakat saat ini. Namun demikian, dibalik penggunaannya yang luas, terdapat potensi bahaya dalam bentuk radiasi elektromagnetik. Tingkat radiasi yang dipancarkan berbeda-beda, seiring dengan dampaknya terhadap tubuh manusia, khususnya pada sistem reproduksi.
Tujuan: Penelitian ini bertujuan untuk mengkonsolidasikan temuan dari penelitian yang ada mengenai pengaruh radiasi elektromagnetik ponsel terhadap susunan histologis testis.
Metode Penelitian: Tinjauan literatur dilakukan dengan pendekatan PRISMA (Preferred Reporting Items for Systematic Review and Meta-analyses), menggunakan database publikasi jurnal PubMed dan Scopus. Sebanyak 133 artikel diidentifikasi melalui pencarian database, dengan kriteria inklusi dan eksklusi

ditetapkan berdasarkan kerangka PICOS. Setelah proses penyaringan, enam artikel memenuhi kriteria yang telah ditentukan dan dianggap layak untuk dianalisis.
Hasil: Hasil penelitian menunjukkan bahwa paparan radiasi elektromagnetik menyebabkan perubahan struktur histologis testis pada hewan percobaan.
Kesimpulan: Kesimpulannya, paparan radiasi elektromagnetik dalam waktu lama berdampak pada komposisi histologis testis pada hewan percobaan.

Kata kunci: *Radiasi Elektromagnetik, Histologi, Testis, Ponsel*

INTRODUCTION

Cellular communication devices have undergone notable advancements over the years, incorporating a range of features and enhanced technology. In addition to their primary function of facilitating communication, cell phones possess the ability to support entertainment, multimedia capabilities, and serve as mini computing devices, particularly valuable in professional settings. The integration of such features and technological sophistication are key factors contributing to the reliance of individuals, notably children and adolescents, on these electronic gadgets. (Tangmunkongvorakul et al., 2020; Zencirci et al., 2018). However, it is important to acknowledge that despite the advancements in technology and the various conveniences that cell phones offer, there exists a potential risk to human health due to exposure to electromagnetic radiation emitted by these devices. This radiation has been a topic of concern in scientific research and public discourse, raising questions about the possible long-term effects it may have on the body. (WHO, 2016)

Some individuals may be unfamiliar with electromagnetic radiation. Cellular phones may communicate via radio waves at particular frequencies, and the production of radio waves is one of the physical causes that cause stress to human body tissue. (Kim et al., 2019) Cell phones emit electromagnetic radiation in the form of a magnetic field. (Misek et al., 2023) This magnetic field has the potential to interfere with the biofield or electromagnetic field generated by various organs within the human body when within close proximity. Consequently, this interference may lead to disturbances in the body's metabolism and physiological processes. (Singh & Kapoor, 2014; Widiningrum et al., 2023) Apart from radio waves, there are also microwaves, which are radio waves that have the highest frequency above 3 gigahertz. (Wong, 2010) Radio Frequency Electromagnetic radiation (RF-EMR) from cell phones does not produce specific heat effects, which will later be absorbed. (Koohestanidehaghi et al., 2024) The effects of RF-EMR include the occurrence of apoptosis pathway, heat shock protein, free radical metabolism, cell differentiation, damage to DNA and plasma membranes. (Kivrak et al., 2017).

Further observation of the impact of electromagnetic radiation from cell phones on the human body turns out to be similar to the impact of electromagnetic radiation caused by radar. (Siddoo-Atwal & Siddoo-Atwal, 2018) This impact is the ability of radar to agitate water molecules in the human body. The agitation caused by electromagnetic radiation depends on its intensity, if the intensity is strong enough then the water molecules are ionized. Microwave agitation events that need to be considered are those with power between 4 mW/cm2-30

mW/cm2. Agitation has the potential to elevate the temperature of water molecules within the cellular structures of the human body, consequently influencing the functionality of the nervous system, the secretory activities of glands and hormones, and ultimately impacting the psychological state of individuals. This phenomenon underscores the intricate interplay between physical stimulation and physiological responses, highlighting the multifaceted nature of the human body's intricate mechanisms. Agitation can raise the temperature of the water molecules in the cells of the human body and this can affect the work of the nervous system, the work of glands and hormones as well as affect human psychology. A study in Finland proved that electromagnetic radiation similar to a cell phone for one hour can affect cell production.

The testicles are one of the most radiosensitive organs, and even extremely modest radiation doses can dramatically affect their functionality. (Gong et al., 2014; Li et al., 2016) Radiation exposure can have a negative impact on quality of life and may lead to a decrease in therapy for individuals with testicular cancer. Electromagnetic radiation has long been recognized as an iatrogenic male reproductive toxin because it may damage normal cells, particularly quickly proliferating spermatogenic cells. Electromagnetic radiation has long been established as an iatrogenic male reproductive poison, as it can affect normal cells, especially rapidly multiplying spermatogenic cells. Susceptibility to radiation injury, and infertility are common post-irradiation problems. Ionizing radiation disrupts normal metabolism, proliferation and differentiation, which can lead to mutagenesis, apoptosis and necrosis of radiosensitive cells. Very detrimental events that occur in the testicles result in several abnormalities in spermatogenesis, potentially resulting in temporary or permanent infertility. Abnormalities include low sperm count, increased abnormal spermatozoa, and defective sperm function. Spermatogonia are very sensitive to radiation; doses as low as 0.1 Gy can damage these cells. (De Felice et al., 2019; Ma et al., 2022; Stukenborg et al., 2018) However, studies in mice suggest that low-dose radiation does not damage host spermatogonia and may stimulate repair of damaged spermatogonial stem cells. Based on the description above, we want to learn more about the influence of electromagnetic radiation on public health, particularly by examining histology pictures of the testicles.

METHODS

This investigation constitutes a non-experimental descriptive analysis employing a systematic literature review (SLR) framework in adherence to established PRISMA checklist criteria. Employing this methodology is crucial in order to contribute to and enhance comprehension of the impact of electromagnetic radiation exposure on the reproductive system, particularly on histological aspects. Research endeavors involve synthesizing dispersed literature, providing empirical evidence or fresh perspectives gleaned from the scrutiny of relevant literature, and subsequently juxtaposing these discoveries in scholarly publications.

The data utilized in this research is derived from secondary sources, specifically research reports published between January 1, 2018, and December 31, 2023. To filter articles, the Publish or Perish (PoP) software is employed to identify keywords aligned with

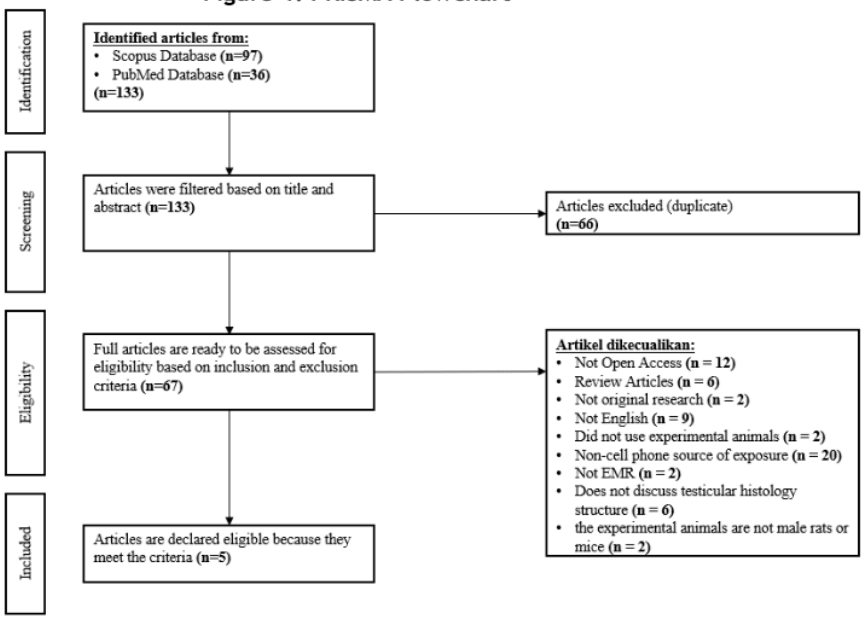
Medical Subject Heading (MeSH) terms such as electromagnetic radiation, histology, testicles, and cell phones. The search for relevant journals is conducted through databases like PubMed and Scopus. (Harzing, A.W, 2007) Additionally, researchers established inclusion and exclusion criteria based on the PICOS framework (Population/Problem, Intervention, Comparison/Control, Outcome, Study Design) to select the articles to be included in this study (refer to table 1). (Eldawlatly et al., 2018)

Table 1. PICOS Summary Framework

Criteria	Inclusion	Exclusion
Population	Samples are experimental animals (rats and mice)	The samples are not experimental animals or other than rats and mice
Intervention	• Radiation exposure is carried out using a cell phone • Exposure source using EMR or EMF	• The source of exposure is not cell phones (Microwaves and other signal transmitting devices) • The source of exposure is not EMR or EMF
Comparation/Control	There is a comparison using a control group	The comparison did not use a control group
Outcome	The results of the observations indicate whether or not there are changes in the histological structure of the testicles due to exposure to EMR radiation	There is no discussion regarding changes in the histological structure of the testis
Study Design	*Original research/Experimental study*	*Literature review*
Publication Years	2018 – 2023	<2018

Articles that meet specific criteria identified through the utilization of the Publish and Perish software will undergo a meticulous two-stage processing procedure. Initially, the titles and abstracts of the identified articles will be meticulously chosen based on predetermined inclusion and exclusion standards. Following this, the complete texts of the articles will undergo a further filtration process utilizing the same set of criteria as previously established. The extraction of data from the gathered articles will primarily focus on aspects such as the experimental animal species utilized, the sample size employed, the frequency of exposure, and the method of exposure. Subsequently, this extracted data will be correlated with observations pertaining to alterations in the histological organization of testicular tissues in animals following exposure to electromagnetic radiation.

Figure 1. PRISMA Flowchart



RESULTS

The process of conducting searches, making selections, and determining the relevance of articles is elucidated through the utilization of the PRISMA flow diagram, as depicted in Figure 1. In order to carry out the search, the researchers employed the use of Publish or Perish (PoP) software, focusing on key terms such as electromagnetic radiation, histology, testicles, and cell phone. In an effort to retrieve appropriate articles, a combination of various keywords including electromagnetic radiation; testicles, electromagnetic radiation; mobile phone; testicles, and electromagnetic radiation; histology; testicles were utilized during searches conducted within the SCOPUS and PubMed databases. The overall tally of articles that were identified amounted to 133, a result of a split between the SCOPUS database, which yielded 97 articles, and the PubMed database, which contributed 36 articles to the total pool of resources.

In the search conducted using Publish or Perish software, a total of 133 articles were identified. The initial stage of filtering involved a meticulous examination of the articles to identify similarities, resulting in the detection of 66 duplicate articles. Following this, a thorough screening process was undertaken, considering various predetermined PICO exclusion criteria along with factors such as the article type (n=6) and non-English language usage (n=9) for exclusion purposes. Regrettably, 12 articles were inaccessible for further analysis, impeding our ability to delve deeper into their content and consequently necessitating their exclusion from the study. The primary focus of this research revolved around experimental studies that investigated the impact of cell phones on radiation exposure, leading to the exclusion of 20

articles that did not align with this criterion. Furthermore, our literature search was specifically geared towards studies involving experimental animals in the form of rats or mice, resulting in the identification of only 3 articles that utilized different experimental animals.

Five articles were deemed appropriate for inclusion in the study based on meeting specific criteria. The experimental subjects utilized in the research varied significantly, encompassing male Albino mice (n=2), male Wistar mice (n=1), male Swiss Albino mice (n=1), and male BALB/c mice (n=1). The focus of this literature review is to outline the methods of EMR radiation exposure employed in each study, particularly those involving mobile phones. The primary objective was to explore the potential impacts of radiation emanating directly from cellular devices on the cellular composition and functionality of testicular tissue, with a specific emphasis on identifying any alterations or disruptions that may arise at the microscopic level as a result of varying durations of EMR exposure.

Study Design	EMR Exposure	Findings	Reference
Adult male Wistar rats (10 weeks old) **(n=16)**	Frequency: **2100 MHz (3G)** SAR: **0.26 W/Kg** Duration: **45 days (2 hr/day)**	Histopathological micrograph of testis in the control group rats shows uniform-sized seminiferous tubules with a well-defined lining of spermatogenetic cells resting on a thin basement membrane, while that of the exposed group indicates the ariation in size of seminiferous tubules, vacuolar degeneration, disruption of germinal layer and reduced number of spermato- genic cells. The present study shows that RF-EMR emitted from mobile phone affects the male reproductive system via increasing oxidative stress, which alters testicular structure and changes the sperm parameters such as sperm count, morphology, viability and membrane integrity in the midpiece and tail of sperm cells.	(Gautam et al., 2019)
Swiss albino male mice (6 weeks old) **(n=30)**	Frequency: **2400 MHz** SAR: **0.087 W/Kg** Duration: **60 days** • Group B (40 min) • Group C (60 min)	Histopathological observations of the testes of control mice revealed the normal architecture of the seminiferous tubule. The seminiferous tubules were hexagonal or rounded and separated by a thin intertubular interstitial connective tissue. In the seminiferous tubules, the spermatogenic cells and the Sertoli cells were regularly arranged.	(Hasan et al., 2021)

Study Design	EMR Exposure	Findings	Reference
Adult male Albino rats (90-120 days old) **(n=70)**	Frequency: **1835-1850 MHz** SAR: - Duration: **15 weeks (3 hr/day)** • Group B1 (30 days) • Group B2 (50 days) • Group B3 (70 days) • Group B4 (90 days) • Group B5 (110 days)	Interstitium tissue contained the interstitial cells (Leydig cells). Irregularities were observed in the germinal epithelium and basal membrane of the seminiferous tubule, together with vacuolization between germinal epithelial cells, undulations in the basal membranes of numerous seminiferous tubules, non-matured germinal epithelial cells in the lumen and vacuolar degeneration were also observed. EMR from cell phones has adverse effects on the germinal epithelium of seminiferous tubules of Albino rats. Exposed groups showed marked decrease in the thickness of germinal epithelium when compared with their controls. This eventually may be associated with infertility.	Jabeen et al., 2021
Male BALB/c mice **(n=32)**	Frequency: **900 MHz Mobile Phone** SAR: **1.3 W/Kg** Duration: **4 hour/day for 30 days**	Many histological change such as degeneration, disorganitation, and desquamation of spermatogenesis cell lineage in the seminiferous tubulus. Dilatation of seminiferous lumen, congestion, oedema in the interstitial tissue and vacuolisation. Sharp decrease in spermatozoa was seen in the lumen of the seminiferous tubule. Oxidative stress induced damaged on testes tissue.	(Shokri et al., 2020)
Male Albino rats **(n=18)**	Frequency: **900 MHz GSM Mobile Phone** SAR: **1.15 W/Kg** Duration: **1 hour/day for 28 days**	Histopathological changes such as loss of germ cells particullary spermatocytes and spermatids associated with absence of spermatozoa. Exfoliation of spermatogonia and Sertolli cells damage. Few seminiferous tubule displayed hyaline material or mass with in their lumen, whish suggest necrosis. Increased percentage of abnormal sperm and decreased motile sperm counts. Induced alteration in the cellular architecture of seminiferous tubule.	(Narayanan et al., 2018)

We describe the EMR radiation exposure method based on the EMR frequency used, the SAR produced, and the duration of exposure in each study. At the EMR frequency, we found 2 studies that used the same frequency at 900 MHz with SAR levels that were not much different. (Narayanan et al., 2018; Shokri et al., 2020) The remaining frequencies used were in the range 1835 MHz to 2400 MHz. (Gautam et al., 2019; Hasan et al., 2021; Jabeen et al., 2021) All of these studies use the same source of exposure, namely cell phones. In terms of exposure duration, we found that most studies conducted exposure to experimental animals for more than 30 days and only one study lasted only 28 days. (Narayanan et al., 2018) The longest radiation exposure was carried out by Jabeen et al. for 15 weeks or 110 days. (Jabeen et al., 2021)

The findings of each study are summarized, demonstrating that exposure to electromagnetic radiation (EMR) over a specific period impacts histopathological changes in testicular tissue and alters the number of various crucial cell types involved in the spermatogenesis process. Both Shokri et al. and Gautam et al. observed an increase in oxidative stress, leading to damage in testicular tissu[13] The majority of studies noted a difference in the size of seminiferous tubules between the exposed and control groups. Narayanan et al.'s research revealed anomalies in sperm cell numbers and a decrease in spermatozoa cells, results also mirrored in the studies conducted by Shokri et al., Gautam et al., and Hasan et al., albeit with varying durations of exposure.

DISCUSSION

Indonesia's population is around 261 million, and 231 million people use cell phones. Thus, Indonesia is in 6th position in terms of cell phone users, based on data from The Spectator Index quoted by Ginting (2015). (Ginting, 2015) In 2015, there were 338 million mobile phone subscribers based on BPS (Central Statistics Agency). Apart from functioning as a communication tool, cell phones offer various features such as browsing, navigation, multimedia, and so on. These various features make people sometimes ignore the potential negative impacts of mobile phones that they may not be aware of. (Kumar et al., 2011) Based on data from the Indonesian Central Bureau of Statistics (2017), mobile phone subscribers in Indonesia in 2011 were 249.8 million, in 2017 there were 435.11 million subscribers, an increase of 49.62%. (Yushardi et al., 2022) A study in 2023 in Indonesia showed that some teenagers found it difficult to control their habit of using cell phones to the point that it interfered with their daily activities. (Lathiifah et al., 2023)

The presence of communication technology in the form of cellular telephones (HP) is inevitable and increasingly sophisticated. Maxwell's formulation highlights the wide frequency range of electromagnetic waves, encompassing light, radio waves, and X-rays. (Jin, 2023) The distinguishing factors of electromagnetic waves from a physical standpoint are their length and frequency. Research indicates that cell phones emit radiation capable of penetrating space in minimal amounts. (D'Agostino & D'Agostino, 2016; Yushardi et al., 2022) Prolonged exposure to such radiation has the potential to induce illnesses like brain tumors, brain cancer, Alzheimer's, fatigue, and min[23]ailments such as headaches. (Hu et al., 2021; Kıvrak et al., 2017; Liu et al., 2024) Nonetheless, some

studies debate the direct correlation between exposure to electromagnetic radiation and the development of these diseases. (Feychting et al., 2024; Karger, 2005; Maffei, 2022)

Cellular devices have the capability to transmit signals within a range of 900 MHz to 1,800 MHz, a phenomenon that is linked to the development of brain tumors and reproductive issues in both males and females. Individuals below the age of 8 are prohibited from utilizing mobile phones due to their heightened susceptibility to the radiation emitted by these devices. (Moon, 2020; Yushardi et al., 2022) Despite efforts to mitigate this risk, such as those observed during the onset of the Covid-19 outbreak, a recent investigation in 2023 revealed a substantial increase in the amount of time children spent in front of screens throughout the period of enforced isolation. (Karaca, 2023)

Numerous factors have been identified as contributors to disorders of the male reproductive system, with the exposure to radiation from mobile phones emerging as a factor that is frequently disregarded (Mannucci et al., 2022). Radiation denotes the emission of elementary particles and energy from a radiation source to the receiving medium (Funk et al., 2016). The evaluation of a cell phone's radiation levels is commonly referred to as the Specific Absorption Rate (SAR). The quantification of radio frequency (RF) energy absorbed by the body tissues of cell phone users can be denoted in terms of watts per kilogram (W/kg). The SAR threshold established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) stands at 2.0 W/kg (ICNIRP, 2020). In contrast, the Institute of Electrical and Electronics Engineers (IEEE) has introduced a novel standard adopted by the United States and other nations, such as Indonesia, which enforces a limit of 1.6 W/kg (Hossaini et al., 2023). Mobile phones are capable of emitting signals within a frequency range of 900 MHz to 1,800 MHz, which possess the potential to induce brain cancer and reproductive issues in both males and females. Individuals below the age of 8 are prohibited from using cell phones due to their susceptibility to radiation exposure (Moon, 2020; Yushardi et al., 2022). Nevertheless, certain circumstances such as the onset of the Covid-19 pandemic cannot be circumvented. A study conducted in 2023 revealed that the majority of children experienced a significant increase in screen time during the lockdown period (Karaca, 2023).

The fertility of male individuals is influenced by a variety of factors, such as sperm production via the process of spermatogenesis (Gabrielsen & Tanrikut, 2016). Spermatogenesis is a highly intricate process of cell differentiation aimed at generating spermatozoa cells (Aitken & Baker, 2020; Szmelskyj et al., 2015). This process commences during puberty, involving three distinct phases: spermatocytogenesis, wherein spermatogonia divide to give rise to a new cell generation responsible for producing spermatocytes; meiosis, where spermatocytes undergo two successive divisions to halve the chromosome count and DNA content per cell to yield spermatids; and spermiogenesis, during which spermatids undergo a complex cytodifferentiation process culminating in the production of spermatozoa (Bilmez & Ozturk, 2023; Suede et al., 2023).

Male individuals who use mobile phones typically store these devices in their pants pockets (Hatch et al.,

2021; Zeleke et al., 2022), leading to a heightened susceptibility to male reproductive issues. According to Miller et al. (2019), research conducted in the United States has demonstrated that men who carry cellphones in their trouser pockets may experience decreased sperm production levels. Furthermore, the sperm generated under such circumstances may exhibit an inability to fertilize successfully or could be rendered sterile due to damage caused by the radiation emitted from the cellphone situated in close proximity (H24ch et al., 2021). Additionally, studies have revealed that the radiation emitted by cell phones can diminish the biological quality of sperm, increase instances of apoptosis, and consequently elevate the likelihood of infertility (Hassanzadeh-Taheri et al., 2022).

Cell phone electromagnetic wave radiation can cause oxidative stress which has an influence on the function and structure of the testicles, in the form of reducing the number of spermatogenic cells. (Ford-Glanton & Melendez, 2018) Another process that occurs to provide an effect is when ROS affect the state of the hypothalamus, which in turn will influence the secretion of gonadotropin releasing hormone (GnRH). (Marques et al., 2022) GnRH will then stimulate the 20 anterior pituitary to influence the secretion of follicle stimulating hormone (FSH) and also Luteinizing hormone (LH). (Darbandi et al., 2018) As a result, there will be an imbalance in the production of the testosterone hormone, which will ultimately affect DNA in the spermatogenesis process and also a decrease in the production of primary spermatocyte 14lls.

Studies examining the effects of electromagnetic radiation (EMR) on the male reproductive system have been carried out on various experimental animals, yielding inconsistent outcomes. Discrepancies arise from multiple variables, including the treatment method, level of radiation exposure, radiation source, and the specific animal models employed, as suggested by Kesari et al. (2018). It is universally acknowledged, based on existing research, that exposure to EMR can potentially harm the histological composition of the testes. A synthesis of available literature indicates that prolonged EMR exposure correlates with increased severity of damage to testicular tissue and other bodily structures (Maluin et al., 2021).

Changes in cell structure observed in studies utilizing experimental animals included alterations in testicular histopathology, a decrease in the quantity of cells crucial for the spermatogenesis process, and an elevation in the presence of anomalous sperm cells. Koohestanidehaghi et al. (2024) elaborated that these anomalous sperm cells stem from compromised motility and cellular architecture, leading to genetic material impairment within the sperm cells. Furthermore, impairment of these cells will inevitably result in male infertility and reproductive issues. A similar phenomenon was documented by Bin-Meferij and El-Kott (2015), where exposure to EMR amplified the population of anomalous sperm cells exhibiting distinct features such as a pyriform head, detached head, and coiled tail. (Bin-Meferij & El-Kott, 2015)

Numerous studies concur that the exposure to electromagnetic radiation (EMR) possesses the capacity to interfere with the process of spermatogenesis. The intricate process of spermatogenesis holds significant importance in the

generation of sperm cells, with the Sertoli cell playing a pivotal role in this process (Ni et al., 2019). Our synthesis of findings from various research endeavors has validated that the exposure to EMR can indeed have an impact on Sertoli cells, as indicated by Narayanan et al. and Shokri et al. Subsequent harm was documented in the tissue of the seminiferous tubule in experimental subjects, with multiple investigations demonstrating anomalous histological characteristics in the seminiferous tubules of exposed cohorts. This impairment is a consequence of the disruption of the structural integrity of the seminiferous tubules at the cellular level. Adebayo et al. (2019) have provided empirical evidence through their research to support the assertion that this harm stems from the influence of radiation on testicular tissue, leading to degeneration (Adebayo et al., 2019). The impairment of seminiferous tubules is anticipated to have repercussions on male fertility rates.

In the human population, electromagnetic radiation (EMR) has been shown to elevate the susceptibility to oxidative stress, a phenomenon exacerbated by the compromised capacity of the testes to counteract this physiological pathway. This assertion is corroborated by the investigation conducted by Shokri and colleagues, underscoring the involvement of oxidative stress in the detriment of testicular tissue (Shokri et al., 2020). A study authored by Agarwal and collaborators in 2014 elucidated that oxidative stress represents a prominent determinant of male fertility, given its potential to disrupt the intricate biological processes of spermatozoa. Moreover, an excess of reactive oxygen species (ROS) has been implicated in the onset of pathologies characterized by peroxidative harm to the male reproductive system (Walke et al., 2023). Darbandi et al. further expounded on this concept, asserting that oxidative stress has the capacity to perturb the hypothalamus-pituitary-gonad (HPG) axis, a pivotal endocrine regulator central to male reproductive physiology (Darbandi et al., 2018).

CONCLUSION

In conclusion, the exposure to electromagnetic radiation emitted by cellular devices possesses the capacity to induce disruptions in the reproductive system of experimental animals, particularly alterations in the histological composition of the testes, and generally exerts influence on the reproductive system in its entirety. This is manifested by a reduction in the diameter of the seminiferous tubules and a decline in the proportion of spermatogenic cells, notably spermatidium. The findings of the examination also indicate that electromagnetic radiation exposure impacts various sperm parameters. The substantial intensity of electromagnetic radiation exposure originating from cellular devices over extended periods has been substantiated to yield significant repercussions. These discoveries underscore the necessity for the regulation of cell phone usage within defined durations to safeguard bodily health against numerous potential detrimental factors. Subsequent investigations into the potential effects of electromagnetic radiation on other bodily organs are warranted, along with the exploration of interventions aimed at mitigating the consequences of radiation exposure.

REFERENCES

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