

# Development of FEA Bioelectromagnetic Model for Male's Electromagnetic Radiation Protective Underwear<sup>\*</sup>

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## Abstract

Electromagnetic radiation is the leading cause of diseases in some special environments. With the development of functional clothing design, simulation technology have been increasingly emphasized. Understanding the electromagnetic radiation protective mechanism through a FEA Bioelectromagnetic model is of great significance for male's reproductive system protection. This 3D FEA Bioelectromagnetic model includes muscle model, pelvic model, thigh bone model, bladder model, prostate model, and testis model. The influence of silver layer and bronze layer on electromagnetic field shielding within a dressed manikin exposed to 915 MHz were investigated. Simulated results indicated that testis were protected mostly by electromagnetic radiation protective underwear and other tissues have received various degrees of damage. Increasing the fabric thickness was an effective method to reduce the electromagnetic radiation energy. Therefore, it is important to develop a bioelectromagnetic model to research the shielding effectiveness of the product. Taking the value of electric field strength, magnetic strength and SAR to evaluate influence from radiation source. The bioelectromagnetic model could help designers to forecast the performance of electromagnetic radiation protective underwear, and the results provide the basis for optimum design.

*Keywords:* Electromagnetic Radiation Protective Underwear; Bioelectromagnetic Model; Shielding Effectiveness

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## 1 Introduction

Electromagnetic environment become more and more complicated, Medical research shows electromagnetic radiation can affect the body's thermoregulation, like atrophy of brain, cataract and lymphoid organs [1-2]. Literatures revealed that the impact of electromagnetic radiation to male's reproductive system [3]. In recent years many research reported that male semen quality is declining. Some previous study on healthy men in the Chongqing area of southwest China also had indicated that semen quality was declining [4]. A variety of Experimental [5] were performed

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<sup>\*</sup>This work was supported by research funding from Shaanxi Province's Research Center of Apparel Engineering and Technology.

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based on mice. Electromagnetic radiation of cellular telephone might have sperm toxicity in mice. A few studies on the physical method have demonstrated the ability to measure the degree of damage in human tissues from electromagnetic radiation, especially in male's reproductive system. Electromagnetic radiation protective underwear plays a key role in the field of electromagnetic radiation protection for human's health.

The FEA (Finite Element Analysis) is a numerical calculation that is widely used in engineering analysis field. From the perspective of functional analysis, finite element analysis method can be applied to solve all kinds of flow field including the material structure, mechanics research, electrical and magnetic field, fully integrated solution thermodynamics, dynamics, acoustics, super unit and fluid-structure coupling [6].

In the research of mechanism analysis, Wang Xiuchen performed some studies on the mechanism of shielding electromagnetic radiation fiber and textile, she also combined the characteristics of human body and clothing structure to explored the source of electromagnetic leakage [7-9]. Shi Xiaoning tested the shielding effectiveness of the clothing material in microwave anechoic chamber [10], and found the direction of the electromagnetic field can significantly affect the shielding effectiveness [11].

In the research of simulation analysis, in 2005, Chen Jiakui established a simplified model to simulate the shielding effectiveness when wearing clothing [12]. In 2009, Liu Chang conducted some studies on the shielding effectiveness in far-field and near-field environment of electromagnetic [13]. Su Zhentao used the foreign anatomy human body model to carry on computational numerical simulation, with a focus on the concrete influence from electromagnetic parameter. He designed a simple cube shape to replace protective clothing [14]. In 2011, Cai Mingjuan developed a human body model and simulated the distribution of electromagnetic energy, which was absorbed by the body when wearing the electromagnetic radiation protective clothing [15]. Zhang Lili used the electromagnetic simulation software Ansoft HFSS to establish a simple model that can analyze the shielding effectiveness of pregnant clothing [16]. In 2016, Zhang Shuyi adopted CST software to build a simple human body model and clothing model. He set up some probes in the human model to simulate the electric field intensity [17]. In 2017, Zhang Weiwei also took CST established five electromagnetic radiation protective clothing models to analyze the shielding effectiveness of their design. His conclusion can guide consumers to choose this kind of clothing reasonably, but he did not describe the physical experimental methods and simulation environment [18]. Sun Lifang calculated the influence of the electromagnetic absorption of the human anatomy model by the FDTD method [19]. Zhang Yongheng used the CATIA software to establish a female human body model and clothing model. He explored the influence from holes and joints in shielding effectiveness [20].

Using simulation technology to solve the problem of special functional clothing design based on human body will become a new trend. The main purpose of this study is to develop a bioelectromagnetic model that takes into account five parts of the human body to research the shielding effectiveness of the electromagnetic radiation protective clothing. This paper adopts the finite element method to establish a model for clothing, antenna, and environment, and a simplified local human electromagnetic model that includes the skin, fat, bones, muscles and the heart. The aim of this study is to forecast the performance of electromagnetic radiation protective clothing, and the results provide the basis for an optimal design.