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The Relationship Between the Testes and the Brain

Rakhimova Gulnoz Shamsievna
Department of Pathological Physiology, Bukhara Medical Institute
https://orcid.org/0009-0003-5023-0656

Abstract

Some evidence suggests striking similarities between the human brain and testes. Understanding these similarities and their consequences has become a matter of interest to the scientific community. Indeed, intelligence has been reported to be associated with several parameters of sperm quality, and there is also an obvious link between human brain and testicular dysfunction. Below we will look at some parameters that indicate the presence of similarities between the brain and the testes.

Keywords: testes, brain, neuron, spermatozoa.

When comparing these tissues, a large number of common molecular features are striking, which are reflected in a huge number of common proteins. At the functional level, human neurons and spermatozoa share many common features, including the importance of exocytosis processes and the presence of similar receptors and signaling pathways. Common proteins are mainly involved in biological processes related to exocytosis, tissue and neuron/brain development. With the help of this analysis, we came to the conclusion that the human brain and testes, in addition to their participation in the speciation process, have some common biochemical features that may, at least partially, be involved in the expression of a huge number of common proteins.

The human body is an organized set of different organs that work together to maintain overall health and homeostasis. The human brain is the control center of the nervous system and plays an important coordinating role. It receives signals from the senses and converts them into functional information in some physiological departments, such as muscles and glands. In addition, the brain is also involved in speech formation, memory retention, and the development of thoughts and emotions. The testes are the male sex glands and play a crucial role in the reproduction and evolution of the species. They perform 2 main functions: the production of gametes (sperm) and the synthesis/secretion of hormones (mainly testosterone).

Despite these completely different functions and the obvious structural and morphological differences between the human brain and testes, over the past 40 years it has become increasingly obvious that these tissues share some common features. The similarity was further confirmed by gene expression analysis, which showed that the human brain and testicles have the most common genes among all organs of the body. Recently, it was discovered that there is a positive correlation between general intelligence and 3 key indicators of sperm quality (sperm concentration, sperm count, sperm motility).

Several authors have also hypothesized a possible link between male sexual dysfunction and neurological disorders. These results raise a number of interesting questions. Why do the human brain and testes have similar gene expression profiles? Do these tissues interact with similar tissues and cell types? Are these features related? What are the consequences of the similarity of the human brain and testes?

In this context, we will consider the similarities between the human brain and testes, as well as between human neurons and sperm cells at the cellular and molecular levels. The proteomic profiles of two human tissues (brain and testes) and two cell types (neurons and spermatozoa) were also compared and critically discussed.

When the human brain and testes, two completely different tissues with very different functions, were compared, several similarities became apparent, covering both the molecular and cellular levels of organization.

The human brain and testes are made up of different types of cells that interact to maintain tissue integrity and function. The human brain is a complex and organized tissue consisting mainly of neurons and auxiliary cells called glia. Neurons are the most important brain cells that transmit information. To maintain their function, glial cells are closely connected to neurons. The human brain consists of 4 different types of glia: astrocytes, oligodendrocytes, microglia and ependymal cells, each of which is necessary to maintain brain function. Similarly, the testis is a well-organized tissue consisting of seminal tubules in which developing germ cells and Sertoli cells interact closely. Next to the seminal tubules and blood vessels are Leydig cells, which produce testosterone and secrete it into the blood vessels. Astrocytes and Sertoli cells are known as biochemical support cells of the brain and testis, respectively. In addition to their important role in the metabolism of these tissues, described below, they are responsible for the physical and nutritional support of neurons and germ cells and are necessary for their development and survival.

The human brain and testes are tissues with high energy consumption that perform energy-intensive processes such as cognitive functions and spermatogenesis, respectively. To meet these energy needs, metabolic interactions between different cell types are observed in both tissues. In the brain, astrocytes produce lactic acid as a product derived from glycogen and use it as a preferred energy source to maintain synaptic activity. Thus, metabolic processes in neurons strongly depend on the activity of astrocytes. Similarly, the metabolically active interaction between developing germ cells and Sertoli cells is obvious. Sertoli cells convert glucose into lactic acid, which is transported as the main energy metabolite during germ cell development and is used to maintain metabolic activity. In addition to similar metabolic interactions, the brain and testes depend on selenium metabolism. A selenium-deficient diet is associated with increased sensitivity to neurotoxicity and impaired spermatogenesis. In conditions of selenium deficiency, castration is mainly associated with a decrease in neurodegeneration due to increased selenium-dependent antioxidant activity in the brain, as the brain and testes compete for the use of selenium.

Compared to other tissues, the human brain and testes are particularly susceptible to oxidative damage due to the high demand for energy and oxygen, as well as an excess of polyunsaturated fatty acids (PUFA). To counteract the high sensitivity to oxidative stress, these two tissues have special barriers between blood and tissues called the blood-brain barrier and the hematotesticular barrier. The important role of high concentrations of PUFA in the functioning and/or development of the human brain and testes has been reported.

In recent decades, the Leydig cells of the testes have been recognized as members of the neuroendocrine system. The synthesis and isolation of a large number of biologically active substances characteristic of nerve and neuroendocrine cells revealed that Leydig cells are neuroendocrine cells. In addition to Leydig cells, Sertoli cells also express several proteins specific to neurons and glial cells. In fact, 3 isoforms of nerve fiber proteins have been found in both Leydig cells and Sertoli cells of the testes.

The brain controls the function of the testes, in particular, due to the secretion of gonadotropin-releasing hormone (GnRH), luteinizing hormone (LH) and follicle-stimulating hormone (FSH) by the hypothalamus and pituitary gland.

Morphology, genomic activity and functions of human neurons and spermatozoa are as different as the other two cells of the body. Spermatozoa are basically haploid cells, which are very special cells compared to other cells of the human body, since they are practically devoid of transcription and translation.

Both neurons and spermatozoa can activate other cells, but the activation mechanisms involved are different. After the plasma membrane of the sperm interacts with the egg, the sperm activates the egg, initiates a cascade of signal transmission and eventually transforms the egg into a diploid embryo. Neurons also have the ability to activate other cells, i.e. other neurons or somatic effector cells, through chemical synapses or slit junctions (electrical synapses) without the need for intercellular contact.

Conclusions: The similarity between the human brain and testes can be explained by biochemical convergence and the participation of these two tissues in the process of speciation. The high protein similarity between the human brain and testes may have clinical significance. Indeed, common proteins may be associated with simultaneous impairment of brain and testicular function. Identifying these proteins, along with analyzing their role in brain and/or testicular function, may help in better understanding the pathophysiology of these conditions, as well as in developing new therapeutic strategies for treating brain or testicular diseases.

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