Physical Education, Health and Social Sciences

https://journal-of-social-education.org E-ISSN: 2958-5996
P-ISSN: 2958-5988

Neural Transmission and its Role in Neurological Disorders

Nosheen Naseem[1,2], Naheed Mumtaz[2], Muhammad Mudassar[3*], Fatima Zahra[3], Fahad Said khan[2], Shamaila Kausar[4], Abdul Hamid Khan[2]. Muhammad Akram[1], Momina Iftikhar[1]

[1]Department of Eastern Medicine, Faculty of Medical Sciences, Government Collage University Faisalabad Pakistan
[2] Department of Eastern Medicine, Faculty of Medical and Health Sciences, University of Poonch Rawalakot Pakistan
[3] College of Allied Health Professionals, Faculty of Medical Sciences, Government Collage University Faisalabad Pakistan
[4] Department of Microbiology, University of Lahore, Pakistan
Corresponding Author Email: drmmudassar@gcuf.edu.pk

DOI: https://doi.org/10.63163/jpehss.v3i3.567

Abstract
The basic process that facilitates the nervous system activity of invertebrates and vertebrates is the transmission of impulses and response to stimuli through the body. This process enables organisms to perceive modifications in their internal and external environment, interpret data, and execute proper behavioral or physiological action. Pulse transmission and response to stimuli should be precise and efficient to maintain homeostasis, survival, and adaptation. If the stimulus is strong enough to be over the suggested threshold, a transient alteration of the brief life of the membrane potential is created. This is referred to as action potential and defines the initiation of the transmission of neuronal effects. This electrical signal is initiated by the transport of ions, especially sodium (Na°) and potassium (K me°). Synaptic permeation is a crucial element of impulse transmission. Action potentials transmitted to the axon clamp fill neurotransmitters in the synaptic gap. Recipe types and neurotransmitters decide if they bind to specific synaptic membrane receptors to decide their excitatory or inhibitory effects. Complex neural networks are produced via communication. This synaptic activity between the threshold and the neuron enables communication. The creation of action potentials is a brief, transient alteration in membrane potential, a brand that employs transmission of neuronal impulses.

Keywords: Action potential, Recovery phase, Nerves outside brain and spinal cord, Activating and blocking signals

Introduction

Neurons are specialized excitable cells that transmit information rapidly through electrical and chemical signaling, enabling sensory perception, stimulus response, and complex behavioral coordination. The soma houses the nucleus and organelles essential for maintaining cell health and synthesizing proteins and neurotransmitters. Dendritic arborization expands synaptic connectivity, allowing integration of inputs from thousands of other neurons. Axons propagate action potentials toward target cells, with myelination and nodes of Ranvier facilitating saltatory conduction and enhancing signal transmission speed. Neuronal diversity—including sensory, motor, and interneurons—underpins the dynamic and highly interconnected architecture of the brain and nervous system.

The resting membrane potential is established and maintained due to the higher concentration of cations in extracellular fluid compared to the cytoplasm. (Xu et al.,2013). Potassium ions (K^+) are more readily transferred across the membrane than sodium ions (Na+), resulting in an excess of negative charges within the cell. The resting membrane potential is determined by the relative concentrations of positively charged K^+ ions inside and outside the membrane. In a resting state, K^+ ions accumulate within the cell due to net migration driven by the concentration gradient. Cells store large amounts of K^+ ions, while Na^+ ions are predominantly located outside neurons.

Negatively charged proteins in the cytoplasm repel calcium ions (Ca^{2+}), which tend to accumulate outside the cell. When a neuron is sufficiently powerful, it can transmit signals downstream, relaying information from other neurons. Neurotransmitters facilitate communication between neurons. To convey signals, a neuron utilizes an action potential, a temporary reversal of the resting membrane potential. Both the central and peripheral nervous systems contribute to stimulus responses. The central nervous system (CNS), comprising the spinal cord, brainstem, thalamus, and cerebral cortex, coordinates and interprets these impulses to generate conscious perception and motor responses. The efficiency of neural circuitry is exemplified by reflexes, rapid, involuntary responses to stimuli mediated by peripheral nerves and the spinal cord.

Neuroplasticity, the nervous system's ability to modify and reorganize through experience and stimuli, adds complexity. Long-term depression (LTD) and long-term potentiation (LTP) are key mechanisms that illustrate how repeated stimulation can either reinforce or degrade synapses, forming the basis of memory and learning

.

Propagation of an action potential along a neuron

An action potential, or nerve impulse, is an electrical signal that propagates across a neuron's membrane. It is initiated when chemical inputs from adjacent cells alter the membrane potential of a neuron. During an action potential, potassium ions (K^+) efflux through ion channels, while sodium ions (Na^+) influx through ion channels, causing the membrane potential to rapidly shift from negative to positive. This shift results in membrane depolarization. The action potential occurs stochastically, commencing only when the membrane potential surpasses a threshold, typically approximately 15 millivolts (mV) greater than the resting membrane potential. Neither of these depolarizations reached the -55 mV threshold. The subsequent rise in the cell's positive charge, reaching approximately +40 mV, initiates the action potential. This process is termed depolarization. The action potential concludes when potassium ion channels open, allowing K^+ ions to exit the cell. The significance of neural transmission in maintaining general bodily function and adaptive behavior is further underscored by ongoing research in this field, which holds promise for advancing therapies for nerve injury, sensory disturbances, and neurodegenerative diseases. (Drukarch et al.,2018)

Electrical potential difference across the cell membrane

Frederick George Donnan (1870–1956), a British scientist born in Colombo, Ceylon (now Sri Lanka), made seminal contributions to colloidal chemistry. Educated at Leipzig, Berlin, London, and Queen's College Belfast, he later held academic positions at the University of Liverpool (1904–1913) and University College London (1913–1937). Donnan's work on ionic equilibrium and membrane phenomena laid foundational principles in physical chemistry. In neuroscience, a typical neuron consists of a soma housing the nucleus and multiple dendrites that receive impulses, while a single axon transmits signals away from the cell body. Bundles of such neuronal fibers, encased in connective tissue, form nerves, which can extend several feet in advanced neurological systems. (Zorova et al.,2018)

Phase of neuronal inactivity after depolarization

When the summation of incoming stimuli exceeds the threshold at the axon hillock, an action potential is initiated in a normal neuron. The threshold required to trigger an action potential is -55 mV, while the resting potential of nerve fibers is typically around -70 mV. The accumulation of sodium ions (Na^+) within the cell, membrane depolarization, and the eventual attainment of the critical potential of -55 mV are the stimuli that trigger an action potential. Following the all-or-nothing principle, an electrical impulse is generated at this threshold and propagates from the trigger zone to the nerve terminals along the axon. The initial phase of the action potential, depolarization, begins when the resting membrane potential shifts from its normal state. The membrane voltage reaches its peak during this phase. During the second phase of the action potential, the membrane attempts to return to its resting state. As previously open ion channels revert to their native conformation, it takes time for the membrane potential to fall back to -70 mV. During this period, an accumulation of negative charge develops within the cell due to certain cations still exiting the neuron. Consequently, the membrane potential can drop to -90 mV before finally returning to its resting potential of -70 mV.

Due to their limited permeability, different ions exhibit distinct concentrations inside and outside the cell. During rest, K^+ ions accumulate within the cell as a result of net movement in accordance with the concentration gradient. Elevated cation concentrations outside the cell maintain the negative resting membrane potential compared to the intracellular cytoplasm and extracellular fluid. The formation of an inward negative charge within the cell is attributed to the fact that potassium ions can more readily cross the cell membrane than sodium ions. Sodium ions are maintained in high quantities outside neurons, while potassium ions are stored in large amounts within cells

. (Evans et al.,2018)

Nervous system elements outside the central nervous system

The intertwining and bundling of nerve cells and their axons form nerve fibers, analogous to the manner in which multiple cloth fibers twist together to create sewing thread. Within this bundle, some nerves transport information to the brain, while others relay information from the brain. The brain and spinal cord receive input from these nerves, which provide a direct connection through spinal or cranial nerves that supply the spinal cord. Sensory nerve connections are located in the posterior region of the spinal cord. Motor connections, or nerves that exclusively relay instructions for muscle movement, are situated in the anterior region of the spinal cord. These nerves inherently control the body's systems and organs. Autonomic nerves typically consist of a mixture of different nerve fibers, some of which transmit instructions from the brain to their target, while others relay information to the brain regarding organ performance. For instance, these organs transmit nerve impulses to the brain via the peripheral nervous system, such as the sensation of satiety after a meal or the feeling of warmth in the stomach following a hot drink.The autonomic nervous system regulates the heartbeat, ensuring blood circulation to the body and brain. The 11 nerves in the skin of the head, face, and neck are responsible for sensing taste, smell, hearing, and touch. Each of the 31 nerve pairs is connected to the spine at approximately the same level as every vertebral segment. These nerves branch into smaller nerves that traverse the entire body, ultimately terminating at the fingers and toes or beneath the skin's surface
. (Comi et al., 2014)

Breast volume augmentation

Saline breast implants are filled with sterile salt water, which is safely absorbed and naturally excreted by the body in the event of rupture. Structured saline implants, containing the same sterile solution but supported by an internal framework, are designed to mimic a more natural feel. Silicone breast implants are composed of a cohesive silicone gel that may either remain confined within the implant shell or slowly leak into surrounding breast tissue if rupture occurs.

Form-stable breast implants

Due to their resistance to folding, even in cases of implant shell rupture, these implants are also referred to as "gummy bear" implants. They are firmer and thicker in composition compared to regular implants, with a greater silicone gel content. Larger skin incisions than those typically required are needed for form-stable breast implants. These implants create a fuller appearance in the breasts. If they migrate, they are less likely to alter the breast's appearance due to their uniform round shape. Among all implant types, smooth breast implants are the softest to the touch. Smooth breast implants, compared to other implants, often provide the illusion of more natural breast movement. Textured breast implants: Textured breast implants reduce the likelihood of breast movement by creating scar tissue that adheres to the implant. Although rare, patients with textured breast implants may experience implant migration. Fat transfer and breast augmentation: In a fat transfer breast augmentation, the surgeon injects fat into the breasts after performing liposuction to remove fat from another area of the body. Individuals seeking a small increase in breast size are typically suitable candidates for this type of augmentation. The implant may be placed either under the pectoral muscle or under the breast tissue and in front of the muscle. (Namnoum et al.,2013). According to Üstün et al.. (2025) report that subglandular breast implant placement preserves peripheral sensation more effectively than dual-plane type II and III techniques, particularly in patients who breastfed and subsequently experienced pregnancy post-procedure.

Aesthetic enhancement

Enhanced flaw concealment: cosmetic procedures can reduce the visibility ofage spots, wrinkles, scars, and sun damage . In some cases, treatments such as chemical peels or laser resurfacing may even restore the skin'syouthful texture and appearance. Additionally, cosmetic adjustments can contour and define the face,makingit appear more juvenile. By minimizing wrinkles, treatments such as botox or fillers can prevent further sun-induced or environment-orientated damage.Faster, more effective skincare products: simultaneously using skincare treatments and products may reduce the needfor future treatments. In general, cosmetic enhancements have numerous benefits, including improved skin care product results andincreased self-esteem. With customized treatment programs that yield natural outcomeswith minimal downtime, theexperts are assisting clients achieve their cosmetic goals and feel and appear their best. (Zheng et al.,2008)

Individualized medical management plans

Individual variations in drug metabolism can result in a high rate of side effects or an inadequate therapeutic response. Personalized psychiatry has emerged to deliver the optimal medication with minimal side effects at the appropriate dose, considering each individual's genetic makeup. Drug treatment personalization methods encompass three categories: genotyping (pharmacogenetics), phenotyping, and blood drug concentration measurement (BDM). BDM monitoring measures plasma drug levels, phenotypic analysis examines the activities of drug-metabolizing enzymes, and polymorphisms of proteins, such as enzymes, transporter proteins, receptors, and other proteins, are determined through genotypic analysis. This article discusses psychopharmacological treatment approaches tailored to the individual. Understanding an individual's genetic, biological, psychological, and social characteristics in detail is the initial step in providing personalized care. This approach focuses on an individual's overall health rather than a specific disease. The "no disease, patient" concept encompasses the patient's physical, psychological, and social needs, unlike conventional treatment. By considering factors such as genetic makeup, lifestyle, and psychological state, this approach aims to create a personalized treatment plan. Consequently, this therapy method refers to medical care or a treatment program tailored to the unique needs, characteristics, medical history, and living situation of each individual. Given the differences in genetic, biological, psychological, and social characteristics among individuals, individualized treatment requires a thorough understanding of the patient and the application of an individualized strategy. Genetic differences influence an individual's susceptibility to illness, response to treatment, and potential adverse effects. Each individual possesses a unique genetic code. The creation of an individualized treatment plan using a patient's genetic information is termed genetically-based individualized treatment. This allows for tailoring therapy to an individual's genetic makeup, exposing patients to less dangerous and more potent drugs. This approach focuses on minimizing potential side effects and maximizing patient response to treatment. Standard drugs in therapy are not used if one knows their genetic makeup. These advancements could potentially cure patients with unprecedented success and precision in the healthcare sector, significantly improving their quality of life.. (Lin et al., 2017)

Emotional well-being concerning body appearance

Although phrased in therapeutic terminology, professional guidance from a trained therapist can be invaluable in addressing complex issues related to body image and self-esteem. Nevertheless, several self-directed strategies can foster healthier perceptions. Identifying and documenting personal triggers—such as thoughts, eating behaviors, and exercise patterns—provides a foundation for self-awareness and change. Cultivating non-judgmental attitudes toward others' appearances, practicing self-control over appearance-based evaluations, and consciously refraining from commenting on physical looks for a set period can help shift focus toward intrinsic qualities and interpersonal interactions. In an era where pervasive media imagery perpetuates unrealistic body ideals, fostering media literacy among both girls and boys is crucial for developing critical engagement with these portrayals. Negative body image is associated with numerous adverse psychological and behavioral outcomes; however, emerging evidence suggests that larger body size alone does not inherently predict poor overall health. (Morales-Sánchez et al., 2021)

Patterns and regulation of blood circulation in the vascular network

As previously mentioned, the pressure exerted by a fluid on its container wall due to gravity is termed hydrostatic pressure. Arterial pressure, or the pressure that blood exerts on blood artery walls or heart chambers, is a form of hydrostatic pressure. Although the term "arterial pressure" is not inherently ambiguous, it is most commonly used to describe the pressure of blood flowing through the systemic circulation's arteries.

Arterial pressure can be recorded from the capillaries, veins, and arteries of the pulmonary circulation. Clinically, this pressure is often measured through the brachial artery and is expressed in units of millimeters of mercury (mmHg). Persistent elevated resting pulse pressures can harm the brain, heart, and kidneys, necessitating treatment. Mean arterial pressure (MAP), or the average force that propels blood into the veins supplying tissues, is calculated as the total number of elements divided by their sum, a concept in statistics. MAP should normally range between 70 and 110 mmHg. Ischemia, or insufficient blood supply, results from a sustained reduction of blood pressure below 60 mmHg, as the blood pressure will not be sufficient to ensure flow to and through the tissues. Hypoxia, or insufficient oxygenation of the tissues, frequently occurs simultaneously with ischemia
. (Zhao et al.,2000)

Pressure of blood flow on the walls of systemic arteries

No other organs possess as many autonomously regulated vascular compartments as the brain, which maintains cerebral blood flow through finely tuned neurovascular mechanisms. Despite fluctuations in systemic arterial perfusion pressure, autoregulatory processes preserve stable cerebral blood flow. Carbon dioxide levels exert a major influence on cerebral circulation, with hypercapnia inducing vasodilation and hypocapnia causing vasoconstriction, whereas oxygen levels have comparatively minor direct effects on cerebrovascular tone. Hypertension, a pathological elevation of arterial blood pressure, reflects the complex interplay of multiple organ systems regulating vascular resistance and cardiac output. Systolic pressure denotes the peak arterial force generated during ventricular contraction, while diastolic pressure represents the minimal systemic pressure preceding the next cardiac cycle. During diastole, blood transitions from the arterial compartment into capillaries as the elastic properties of large conductive vessels (the "Windkessel effect") maintain forward flow and dampen pressure fluctuations. Baseline blood pressure during spontaneous inspiration is influenced by ventricular interdependence, where reduced left ventricular filling and increased afterload occur due to intrathoracic pressure changes. Conversely, in certain pathological conditions, a paradoxical pulse may arise, characterized by exaggerated declines in systolic pressure during inhalation under positive pressure ventilation. (Furlan et al., 1990).According to Lei et al. (2024) brain- derived neurotrophic factor is crucial in avoiding myocardialdiseases.

Countermanding neural signals controlling neuron activity

Inhibiting or canceling the nerve signals that regulate neuron activity is a complex biological process. Through this mechanism, the brain filters out unnecessary or harmful messages and forwards only the essential information. This process aids in maintaining the balance of the nervous system and regulating the body's movements and responses. The environment continually provides us with information in the form of sights, sounds, and sensations. Some of these require immediate attention, while others are transient. Our brain's neurons are the cells that store information about these inputs and trigger a response. They achieve this by establishing networks with one another, ranging from microcircuits consisting of a few cells to those that regulate multiple processes in various locations. These networks enable us to construct a complex and fairly accurate mental representation of the world by successfully linking disparate pieces of information. While an action potential typically involves numerous excitatory connections, every neuron is subjected to hundreds of convergent electrical impulses at all times. Total excitatory/inhibitory (E/I) balance refers to the quantifiable effect of all excitatory and inhibitory currents a cell is exposed to. Inhibitory neurons constitute a diverse and populous group that regulates the activity of their excitatory counterparts, even though the cortex contains far more excitatory neurons. When the proportion of E/I activity remains fairly stable across a range of different situations, it is described as being balanced.

Orderly brain function—namely, our brain's ability to consistently process environmental information and integrate it with prior knowledge—depends upon E/I balance. Consequently, neuroscientists are interested in studying it. Most E/I balance research is conducted within the cortex and hippocampus, two brain regions associated with higher-order thought and memory. A specified time frame, ranging from milliseconds to half a second or longer, can also be employed to examine E/I balance. The generation and stabilization of E/I balance remain largely controversial. Its usefulness in various brain functions, including feature recognition and sleep, is well-established. One of the proven methods for addressing these problems is intracellular recording, which isolates a portion of a cell on the tip of a hollow glass needle with an electrode attached to record the voltage or current within the cell
(Sotero et al.,2007)

Conclusion

For organisms to perceive their environment, process information, and react appropriately, impulse transmission and stimulus response are essential. Among the highly specialized components of the nervous system required for these processes are neurons, ion channels, synapses, and sensory receptors. Synchronized chemical and electrical impulses enable rapid communication supporting reflexes, voluntary movements, and highercognitive functions. Understanding these mechanisms underscore the nervous system's remarkable efficiency and provides critical insights regarding neurological health and disease.

References

Comi C, Magistrelli L, Oggioni GD, Carecchio M, Fleetwood T, Cantello R, Mancini F, Antonini A. Peripheral nervous system involvement in Parkinson's disease: evidence and controversies. Parkinsonism & related disorders. 2014 Dec 1;20(12):1329-34.

Drukarch B, Holland HA, Velichkov M, Geurts JJ, Voorn P, Glas G, de Regt HW. Thinking about the nerve impulse: A critical analysis of the electricity-centered conception of nerve excitability. Progress in Neurobiology. 2018 Oct 1;169:172-85.

Evans MR, Majumdar SN. Effects of refractory period on stochastic resetting. Journal of Physics A: Mathematical and Theoretical. 2018 Nov 30;52(1):01LT01.

Namnoum, J. D., Largent, J., Kaplan, H. M., Oefelein, M. G., & Brown, M. H. (2013). Primary breast augmentation clinical trial outcomes stratified by surgical incision, anatomical placement, and implant device type. Journal of Plastic, Reconstructive & Aesthetic Surgery, 66(9), 1165–1172.

Lei, M., Liu, Q., Nie, J., Huang, R., Mei, Y., Pan, D., ... & Liu, W. (2024). Impact and mechanisms of action of BDNF on neurological disorders, cancer, and cardiovascular diseases. CNS Neuroscience & Therapeutics, 30(12), e70138.

McMahon, F. J., & Insel, T. R. (2012). Pharmacogenomics and personalized medicine in neuropsychiatry. Neuron, 74(5), 773–776.

Morales-Sánchez, L., Luque-Ribelles, V., Gil-Olarte, P., Ruiz-González, P., & Guil, R. (2021). Enhancing self-esteem and body image of breast cancer women through interventions: A systematic review. International Journal of Environmental Research and Public Health, 18(4), 1640.

Sotero RC, Trujillo-Barreto NJ. Modelling the role of excitatory and inhibitory neuronal activity in the generation of the BOLD signal. Neuroimage. 2007 Mar 1;35(1):149-65.

Üstün, G. G., Sert, B., Demirli, Z. N., Dağ, O., Uzun, H., & Özgür, F. (2025). Long-term breast sensation following breast augmentation: A retrospective analysis of influencing factors. Journal of Plastic, Reconstructive & Aesthetic Surgery, 104, 351-358.

Xu N. On the concept of resting potential—Pumping ratio of the Na+/K+ pump and concentration ratios of potassium ions outside and inside the cell to sodium ions inside and outside the cell. The Journal of Membrane Biology. 2013 Jan;246:75-90.

Zheng, P., Luque-Ribelles, V., Gil-Olarte, P., Ruiz-González, P., & Morales-Sánchez, L. (2021). Enhancing self-esteem and body image of breast cancer women through interventions: A systematic review. International Journal of Environmental Research and Public Health, 18(4), 1640

Zorova LD, Popkov VA, Plotnikov EY, Silachev DN, Pevzner IB, Jankauskas SS, Babenko VA, Zorov SD, Balakireva AV, Juhaszova M, Sollott SJ. Mitochondrial membrane potential. Analytical biochemistry. 2018 Jul 1;552:50-9.