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Epilepsy Treatment Watch

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Abstract

Epilepsy is a disorder in the electrical charges in the brain. About 3.4 million people suffer from epilepsy in the United States of America. In this paper, an artificial intelligence system was designed for a smart medical watch that can be worn to alert epilepsy before, during, and after it occurs. The watch can accurately monitor an epilepsy patient and give the necessary alerts to his family and the treating physician via a smart phone application. This watch can give the patient's location through the Geographic information system. The diagnosis of epilepsy is based on the amount of increase or decrease in some hormones, such as dopamine and aldosterone, which lead to an increase or decrease in the amount of heartbeat and blood pressure. The watch also stimulates the brain wirelessly using electrical pulses to reduce and inhibit epilepsy as a therapeutic measure.

*The research depended on some sensors to determine the difference in the blood pressure and heart beats such as: **Heart rate sensor. Vibration sensor. Tilt sensor**. For the wireless electrical stimulation of brain used standard voltages and frequencies considering tissue resistance 100 ohms. The stimulation of the brain in the watch is two types one is all time stimulating the second is critical stimulation during the seizures to inhibit epilepsy. This wearable digital technology may fill several critical gaps in epilepsy care. Accurate seizure detecting this this technology can provide data on seizure frequency, used to tailor medical treatments and identify treatment failures. In addition, when seizure detection is paired with alarm feature.*

Keywords:

- **Epilepsy:** Kind of neurological diseases sometimes make body vibration and loss of consciousness.
- **Dopamine Harmon:** The responsible Harmon of heartbeats.
- **Aldosterone Harmon:** The responsible Harmon of blood pressure.
- **Stimulation of brain:** Smart technology to stimulate brain cells.
- **Biological cell Voltage:** The voltage difference between sodium and potassium.

Introduction

The history of seizures and epilepsy may date back to prehistoric times, perhaps as early as the late Paleolithic period. Beliefs on the causes of seizures coincided with the prevailing concept of religion and medicine of that era, with ideas changing over time from a magical to scientific explanation. To comprehend how a disease came to be, we must begin with a description of the signs and symptoms, followed by names and definitions, which is intimately tied with an understanding of the pathophysiology [7].

Sodium and potassium are the two basic elements in the formation of biological cells. Therefore, they are the two elements responsible for diseases and how to treat them by increasing or decreasing them. This is what we rely on in diagnosing and treating epilepsy, but epilepsy has many types and their symptoms also differ, and the types of epilepsy include:

- **Focal epileptic seizures:** These are seizures that result from activity in only one area of the brain.
- **Generalized epileptic seizures:** It affects all parts of the brain and will be the field of this study.

Generalized epileptic seizures are divided into:

- **Epileptic seizures accompanied by absence:** It affects children, such as staring.
- **Tonic epileptic seizures:** Tonic epileptic seizures cause muscle stiffness and may affect consciousness.
- **Atonic seizures:** Causes loss of muscle control.
- **Clonic seizures:** It causes repetitive twitching muscle movements.
- **Myoclonic seizures:** It usually appears in the form of short twitches or spasms.
- Tonic-clonic seizures

They are previously known as grand epilepsy seizures, and they are the most difficult type of seizures. They can cause a sudden loss of consciousness, stiffness, spasms, or tremors in the body, and sometimes lead to a loss of the ability to control the bladder or bite the tongue. This type of seizure will be the scope of these study. Most physical activities, such as walking, running, thinking, etc., send their signals from the brain in a process called action potentials, where the biological cell consists of the element Sodium and potassium.

People with epilepsy tend to have more physical problems (such as fractures and bruising from injuries related to seizures), as well as higher rates of psychological conditions, including anxiety and depression. Similarly, the risk of pre mature death in people with epilepsy is up to three times higher than in the general population, with the highest rates of premature mortality found in low – and middle-income countries, are potentially preventable, such as falls, drowning, burns and prolonged seizures [8].

When a biological cell is at rest, the concentration of sodium inside the cell is less than the concentration of potassium, which is known as polarization. When a person wants to move or perform any activity, the sodium pumps are opened to pump sodium into the cell, so that the sodium ions inside the cell become more than potassium ions, which is known as depolarization. Our goal is to prevent the depolarization process that causes unwanted movement by reducing the sodium concentration inside the cell during, before and after epileptic status by wireless electrical stimulation of the brain [3].

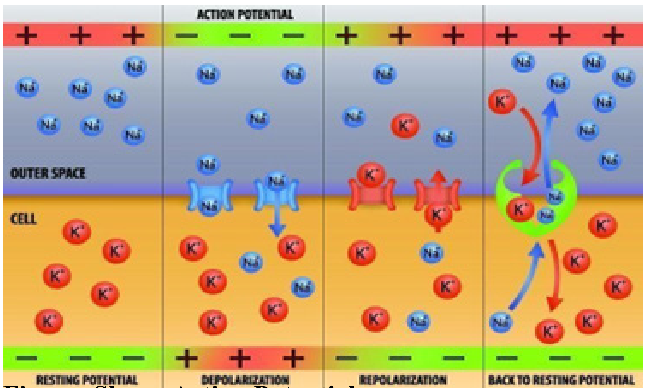


Figure: Shows Action Potential

Research Hypothesis

In the usual way, the case of epilepsy is diagnosed in the neurology clinic using a brain wave display device to show the epileptic waves in the brain, which clearly shows the treating physician the shape of the epilepsy wave, as in the following figure:

Our new method that we want to follow is based on analyzing the phenomena of polarization and depolarization in diagnosing and alerting in the event of epilepsy.

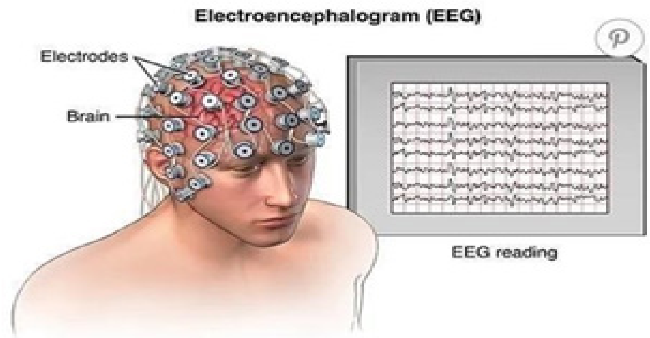


Fig: Shows EEG

Polarization

This is the situation in which the cell is at rest, which is the normal situation. In this case, the percentage of potassium inside the cell is greater than the percentage of sodium, and the cell potential difference in this case is -70 millivolts to -55 millivolts. In this case, the normal percentage of potassium inside the cell is 150 mmol per liter, and outside the cell the potassium percentage ranges between 3.5 and 5 mmol per liter. In this case, the cell is balanced and does not produce any action due to the balance of the sodium and potassium elements inside and outside it.

Depolarization

When external stimulation occurs for the nerve cell to begin making a movement or activity, the pumps controlling the pumping of sodium and potassium pump an amount of sodium until the cell voltage moves from -70 to -55 millivolts, which is known as the threshold voltage, and here the cell begins to work the action potential to send the necessary electrical signal. For an action, such as moving the hand, walking, talking, etc. Here, the potassium levels begin to decrease inside the cell until the cell voltage becomes +40 volts, which is the highest value of the action potential wave. Then it begins and gradually decreases until it reaches zero, then to -70 millivolts, which is the normal situation. For the effort of comfort.

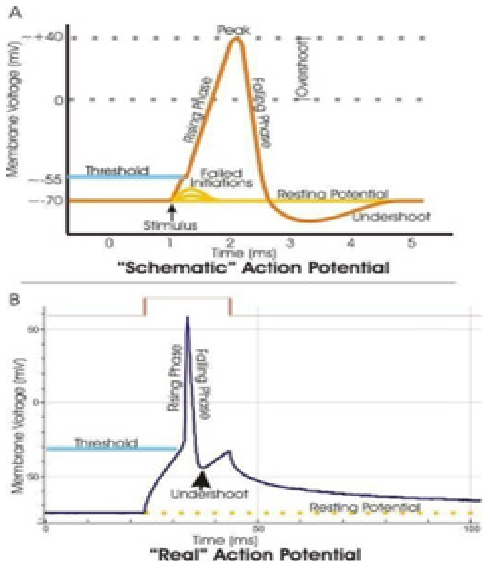


Figure: Show action Potential Wave Form

Epileptic Seizures

In cases of epilepsy, the cell depolarizes to produce an action potential in a random, involuntary manner due to an epileptic seizure. Quantities of sodium are pumped into the cell, amounting to 55 mmol to the power of 5, and the potential difference in the cell reaches +20 volts, while the percentage of potassium in Blood or outside the cell to +12 mmol raised to the power of 2 here as a result of the sudden increase in the proportions of chemical elements inside and outside the cell. The increase in potassium outside the cell leads to an increase in the dopamine Harmon, which leads to an increase in heart rate, which is the first mechanism used in diagnosis. At the onset of epilepsy and when potassium increases in the blood, it leads to a decrease in the Aldosterone Harmon, which leads to a decrease in blood pressure, which prompts the aldosterone pumps to pump more of the hormone to equalize the percentage of potassium in the blood and regulate blood pressure until blood pressure rises, which is the mechanism. The second is in diagnosing epilepsy [6].

	Typical rest			Typical peak during seizure			
ion	$[ion]_i$	$[ion]_e$	E_{ion}	$[ion]_i$	$[ion]_e$	E_{ion}	Reference
K^+	96 mM[1]	4 mM	−85 mV	94 mM	12 mM[2]	−55 mV	Jiang and Haddad (1991) and Dreier and Heinemann (1991)
Na^+	10 mM[3]	145 mM[4]	+71 mV	55 mM[5]	139 mM[4]	+25 mV	Dietzel et al. (1982), Diarra et al. (2001) and Rose and Konnerth (2001)
Ca^{2+}	70 nM	2 mM	+137 mV	700 nM[6]	100 μM[7]	+66 mV	Pumain et al. (1985) and Pal et al. (1999)
Cl^-	7 mM	145 mM	−80 mV	26 mM[8]	152 mM[4]	−47 mV	Raimondo et al. (2013) and Ellender et al. (2014)
pH/HCO_3^-	7.2/15 mM	7.4/24 mM	−13 mV/−13 mV	7.05[9]/10 mM	7.405[10]/25 mM	−25 mV/−25 mV	Caspers and Speckmann (1972) and Raimondo et al. (2012a)
Receptor	Relative Permeability		$E_{receptor}$			$E_{receptor}$	
AMPAR	$K^+:Na^+$/1:1		9.1 mV			0.4 mV	
$GABA_AR$	$Cl^-:HCO_3^-$/4:1		−70.6 mV			−45.8 mV	

$[ion]_i$ and $[ion]_e$ indicate the intracellular and extracellular, free ion concentrations, respectively. E_{ion} and $E_{receptor}$ indicate the reversal potentials for ion species and neurotransmitter receptors, respectively. In calculating HCO_3^- concentrations and $E_{HCO_3^-}$ we have assumed that carbon dioxide is equilibrium distributed across the plasma membrane and that the CO_2 hydration reaction inside and outside the cell is under equilibrium. Values in gray have been estimated where data is not available.

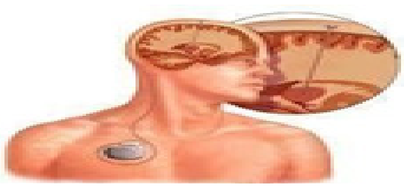
Table: Chemical Elements Rates

Epilepsy Treatment Mechanism

Usually, cases of epilepsy are treated electrically with deep brain stimulation by placing a device in the chest of the person suffering from epilepsy through surgery. The device is connected to the internal vagus nerve of the neck. When the device is opened and the electrical circuit is closed, electrons flow to the brain, which leads to the occurrence of an electric field where the electrons are attracted and it will be Released from the device into sodium ions, the sodium turns from an iron into an inactive atom. In this way, we have reduced the percentage of sodium in the cell and treated epilepsy.

In our method, we followed the issuance of electrical energy from the watch by hand without surgery. This watch emits electrical pulses every time period with a certain voltage and current. When the condition occurs, the watch emits more electrical energy to treat the condition, then returns to normal to issue less energy when the condition stabilizes.

Electrical stimulation of the brain has contributed to reducing cases of epilepsy by 40% [1].



Figure; Shows Deep Brain Stimulation by Surgery

Research Methodology

In my design of the watch, I relied on theories of electronic circuits and some electronic sensors. Among the goals of the watch are:

1. Alert about the occurrence of epilepsy.
2. Treating epilepsy through wireless electrical stimulation of the brain.
3. Giving the patient's location by sending a text message to the patient's relatives and the treating physician to determine his location and view his health condition.

I used an STM32 microcontroller that is programmable in C language using the cubemx program.

Figure: Epilepsy Watch

The Sensors used in the Study are

Heart rate sensor: The heartbeat of a healthy person is (100-160) per minute, so the sensor is set when the heartbeat increases from (180-120) per minute. This means the presence of epilepsy.

Blood pressure sensor: The blood pressure of a healthy person is 120/80 mmhg, so when the blood pressure decreases, this means that potassium has been pumped out of the cell into the blood, and it heralds the beginning of an epileptic state, so the microprocessor starts comparing with the rest of the sensors, and the aldosterone hormone begins to flow, which leads to an increase in blood pressure, which confirms The presence of status epilepticus, and blood pressure in case of epilepsy is (140/90) mmhg.

Vibration sensor: Due to the presence of vibration in the hand here, the microprocessor begins to compare the vibration waves to give a result of the presence of an epileptic condition. This diagnosis is useful for epilepsy patients who have diseases other than epilepsy that involve blood pressure and heart rate. This will certainly be more accurate than relying on diagnosing blood pressure and heart rate only.

Tilt sensor: Here also the sensor detects whether the patient fell or not and compares the result, and here also an increase in the accuracy of diagnosis [2].

Wireless Electrical Stimulation of Brain

It is a modern technology that uses deep brain stimulation wirelessly and works in two ways:

1. Little stimulation at all times: It is done using a small current of 100ma and a voltage difference of 3v if we consider the tissue resistance to be 1000 ohms.
   With a frequency of 0.00006 Hz.
2. High stimulation at the moment the situation occurs: Here the stimulation is to stop the condition and is done using a current of 200A with a voltage difference of 1mv and a frequency of 2Hz [5].

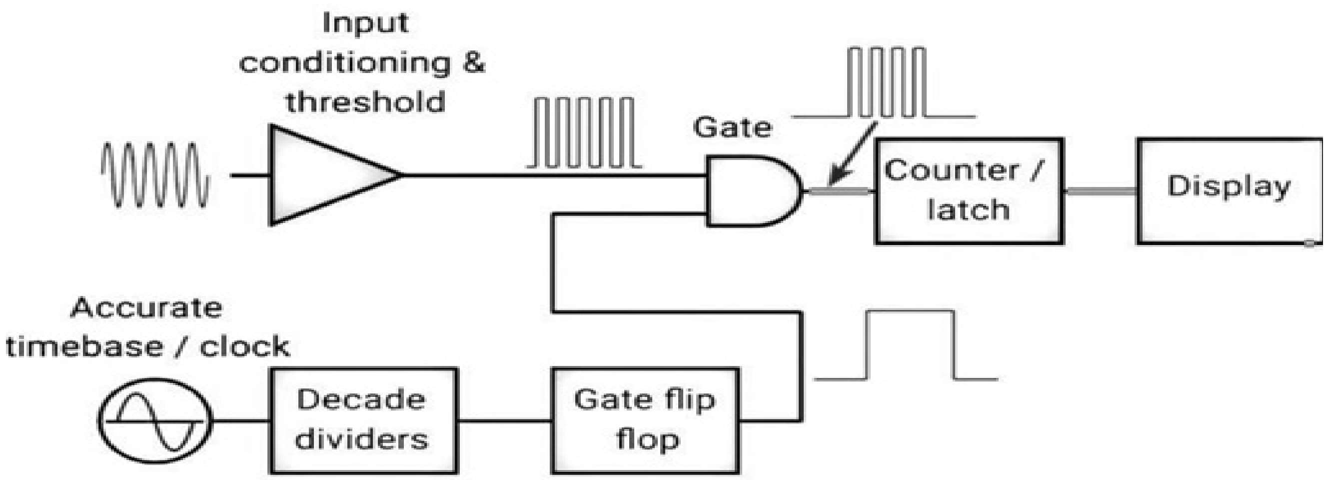


Figure: Shows System Block Diagram

Literature Review

1. Professors at Eindhoven university of technology developed a smart bracelet to detect night epilepsy during sleeping but this way of detecting epilepsy seizures is not effective because it is just working for night seizures [2] but our epilepsy treatment watch is effective and working all times.
2. Scientists at myoclonic hospital did a surgery to epilepsy patient to stimulate his brain by putting electronic device in his chest and connect it with internal Vegas nerve [1] this methodology is is not better for patients but our wireless electrical stimulation is used without surgery.
3. The other natural ways to detect the epilepsy seizures is done by the neurologist in the neurological clinic but with our technology patients do not need to go to clinics because the watch will send the health condition of the patients by smartphones application.
4. Dr. Leung and his team did an experiment to analyze (EEG) diagram using (ECG) electrocardiography but in this method depending on heart rate just for diagnosing epilepsy is not effective because some patients have heart diseases and epilepsy disease [16].
5. Colleen Hanlon led 76 researchers from four continents in writing an article about brain stimulation as an innovative tool for addiction.
6. Bianca Simons Meier and other researchers evaluated weather stimulating the brain noninvasively with a weak current enhances physiological and cognition or assessment performance which has attract massive public interest. they present the first metallic analytic test of the hypothesis that tes in a learning phase is more effective than test in an assessment phase . They achieved good results but stimulating brain by using electrodes is old way [17].
7. Mikael Habtamu designed Alerting systems using a wearable sensor but their new innovation they used a smart real time sensor. The real time sensors are very important

in these projects because the alarms must be in time [18].

8. At johns Hopkins university they made adult epilepsy monitoring unit they used (EEG) device to show the effects of medications in the brain however some epilepsy seizures does not treat by medication [19].

Results and Tests

Through the readings and results, we have shown that it is possible to design an electronic system that alerts when an epilepsy occurs and treats the disease by using wireless electrical stimulation of the brain in a modern, innovative and accurate way. This device is also useful for the treating physician because it enables him to follow up on his patients remotely. Via phone application. This Review explores recent advancements in wearable digital health technology specially designed to manage epilepsy epilepsy presents unique challenges in monitoring and management due to the unpredictable nature of seizures. Wearable devices offer continuous monitoring and real time data collection. Wearable technology is important in epilepsy management because it enables early detections, prediction, and personalized intervention.

Conclusion

In conclusion, this review has illuminated the pivotal role of wearable digital health technology in managing epilepsy, addressing the challenges inherent in traditional approaches while presenting new opportunities for personalized care. By harnessing continuous monitoring and real time data collection these devices offer invaluable insights into seizure patterns and trends, empowering patients and healthcare providers to make informed decisions and take proactive measures. The implications for clinical practice are profound as wearable technology enables more comprehensive and timely interventions, potentially leading to improve outcomes and quality of life for individuals with epilepsy. We can advance the wearable digital health technology field and continue to enhance epilepsy care, ultimately benefiting patients and healthcare system alike.

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