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ELECTROCARDIOGRAM AS A DIAGNOSTIC TOOL: UTILIZATION AND BENEFITS IN EXERCISE SETTING

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Abstract
This paper examines electrocardiogram as a diagnostic tool: utilization and benefits in an exercise setting. An electrocardiogram (ECG) plots the electrical impulses that control the contraction of the human heart muscles which depends on the complex flow of information encoded in electrical signals within the nervous system. The paper succinctly highlights the human body as a volume conductor of electricity, with the arms, the legs functioning as if they are wires connected to the human heart; ECG leads-views to the human heart, nervous stimulation of the human heart as well as ECG and the human heart function; and ECG interpretation of what, to expect during an ECG testing including the importance of ECG to man. Further, this paper highlights common symptoms that frequently require an ECG, and those that require an ECG test. To improve the cardiovascular system, cardiovascular exercise training (CET) and exercise prescription based on type, mode, intensity, frequency, and duration with special consideration were considered. During the process of recovery, patients are advised to slightly increase their heart rate but not more than 20 to 30 beats above rest while the Borg RPE scale (9-11 points) and MHR scale were closely used to monitor signs and symptoms of the exercise intolerance. It is recommended that people who are on the occupation that places great stress on the human heart, as well as people older than age 40, need a baseline electrocardiogram test done before problems develop.

Keywords: Electrocardiogram, Diagnostic, Utilization, benefits of exercise, Volume conduction.

Introduction
The human heart is made of muscles called cardiac muscles which slightly differ from skeletal muscles, both in functions and structure. Skeletal muscles are electrically stimulated to contract while heart muscles depolarize or contract spontaneously in the absence of external stimulation (Zao et al., 2006). The greatest performance and the simplest everyday acts depend on a rapid, complex flow of information encoded in electrical signals within the nervous system and the rest of the body (Azubuike & Amechi, 2011). Differences and distribution of electric currents and potentials in the human body systems occur in three structures (heart, brain, and skeletal muscles) dimensional conductor of electricity (volume conductor) rather than wires. Volume conduction is a salt solution which has body fluids, through which current is capable of travelling in three dimensions. Volume conduction is a word that is adopted in bioelectromagnetism and is describes the transmission of both magnetic and electric fields from the primary electric current source via a body tissue towards sensors used for measurement. Commenting on this, Azubuike and Amechi (2011) point out that the human body is an example of a volume conductor because all body fluids contain electrolytes in which electrical impulses pass. Therefore, as the body is a conductor of electricity, the arms, legs, and chest surface function as if, they are wires connected to the human heart.

Electrical impulses are generated in the sino-atrial node (S.A. node) in the atrium by the right (right atrium) of the human heart could be conducted and spread throughout the myocardium as well as monitored and picked up on the surface of the skin with a special and well-placed electrode to give information about the human heart. Such collection and record-keeping of electrical activities of the human heart with a no-invasive technique monitored from different positions on the surface of the skin are known as Electrocardiogram (ECG or EKG). At the human heart of all exercise matters concerning human health is the human heart (Atare & Mong, 2006).

Electrocardiogram

The electric signals that regulate the contraction of heart muscles are plotted on an electrocardiogram (ECG), which remains an important diagnostic instrument for measuring and recording the electrical activity of the human heart in great detail (Walsh et al., 2006). ECG gives valuable insight and information concerning the anatomical orientation of the human heart, the relative sizes of its chambers, its rate of pumping blood, disturbances of rhythm and conduction, including the extent, location, pressure, and ischemic damage to the myocardium, the effects of altered electrolytes concentration and the effect of certain medications and drugs. To practice the use of an electrocardiogram, it is essential to gain an understanding of how an ECG provides vital information about the health condition of the human heart, and basic knowledge of the anatomy and physiology of the human heart. The human heart is a cone-shaped muscular device or organ with four chambers whose physiological property requires it pumps blood all around the human body. The human heart is structured into two main halves, one half towards the left (left heart) and the other half towards the right (right heart) both of which function simultaneously (Moore et al., 2009).

A smaller chamber in the upper part of the heart is called the atrium (singular atria) and a bigger lower chamber referred to as the ventricle makes up each side of the human heart. The atrium by the right and the ventricle by the right, as well as the atrium by the left (left atrium) and ventricle by the left (left ventricle), are the four chambers of the human heart. The direction of blood flow via the human heart is also represented by this sequence. The atrium by the right (right atrium) receives blood flow back to the human heart through two big veins – the superior and inferior vena cava that has completed a movement through the body and is run out of oxygen and other important nutrients (Longo et al., 2011).

The large vein - superior vena cava – has the role of transporting blood (all cells and nutrients) from all parts of the body (arms, head, neck, and upper part of the chest) to the lower inferior vena cava, the part of the human heart which is responsible for conveying blood from other parts of the body not covered by the superior vena cava. A fraction of a second later, the atrium by the right (right atrium) circulates blood into the ventricle by the right (right ventricle), while the ventricle by the right (right ventricle) sends blood via the pulmonary arteries (left and right) to the lungs for oxygenation. Blood enters the atrium by the left (left atrium) and is pumped into the ventricle by the left (left ventricle) after passing through the lungs. The ventricle by the left (left ventricle) then pumps the blood back into the human circulatory system of the blood vessels (arteries, veins, and capillaries) through the aorta, the body's largest artery (Gordon, 2013).

The ventricle by the left (left ventricle) is a powerful pump, it exerts sufficient pressure to ensure the blood continues its movement throughout all the blood vessels of the body. When one's blood pressure is checked, it is the pressure generated by the ventricle left (left ventricle) that gets read/measured. The human heart is the only muscle in the human body that never rests and like other tissues in the human body, it requires oxygen for function. Thus, the human heart has reserved oxygen and blood for itself through coronary arteries. These arteries which exist in groups usually form/start less than an inch and a half from where the largest artery, the aorta begins. They ensure the human heart muscles and nerve cells are always oxygenated. In an event where the flow of blood via a coronary artery is interrupted in part or in whole, the part of the human heart muscle or nerve affected by the impeded supply begins to suffer and subsequently begins to die – this condition is commonly referred to as coronary artery disease (CAD) (Taji, 2013). If this continues the human heart begins to lose its strength and ability to continuously pump the blood for the entire body’s needs, this resulting condition is now commonly referred to as heart failure (myocardial infarction). In some situations, the interruption of blood flow to the heart through the coronary arteries is temporary and short-lived, sometimes only lasting for a few minutes, this condition is felt and may not result in any significant damage to the heart and its nerves, these symptoms usually indicative of an issue with the heart is called angina (Gordon, 2013). If the arteries that supplied blood to the brain (carotid arteries) are interrupted it could lead to stroke (partial or complete paralysis of the body). Of course, if the arteries that supplied blood to the legs (iliac artery) are interrupted, it could lead to gangrene (a sore that refused never to heal) (Lindskog et al., 2015).

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Nervous Stimulation of the human heart

The function of the human heart is vital to the function of the human body, as essential to the extent that it has its electrical system to ensure that it runs independently of the rest of the human body's nervous system. This is enhanced through parasympathetic and sympathetic nervous systems that innervate the human heart. The sympathetic nervous system is excited/stimulated, which causes the human heart to contract faster and harder. The depolarization rhythm of the sinoatrial node is reduced when the parasympathetic nervous system (vagal nerves) is stimulated, and the transmission of excitement through the atrioventricular node is slowed. The human heart will cease beating if vagal excitement/stimulation is severe. The ventricles start beating again after a brief period. This is referred to as vagal escaped and may result from sympathetic reflexes and/or the initiation of a rhythmical action by the Purkinje fibres (Zao et al., 2006). Owing to its independent nervous stimulation, the human heart often beats normally for instance when the human heart is beating under resting conditions even in a situation of severe brain damage.

This is an extensive network of nerves that run through the four (4) chambers (cavities) of the human heart. Electrical signals/impulses pass via the nerves of the heart to activate its chambers to contract in a perfect and well-structured synchronized timing much like the distributor and spark plugs of a car which make sure that an engine's piston fire in the right sequence. The ECG takes records of the electrical activities of the human heart and depicts it as a series of graph-like tracings, or waves. The shapes and frequencies of these tracings reveal abnormalities in the human heart's function (Wagner et al., 2002).

Interpretation of those details allows diagnosis of a wide range of heart conditions (Azubuike & Amechi, 2011). These conditions can vary from minor to life-threatening. Tuma and Houser (1982) noted that ECG can provide useful diagnostic information about the human heart and its electrical activity; and also emphasized that the electrocardiogram gives no direct information concerning the contractility of the myocardium or the mechanical performance of the human heart as a pump.

The electrocardiogram as a concept was introduced by Willem Einthoven in 1893 at a meeting of the Dutch Medical Society. Over time the ECG has evolved and in 1942, the standard 12-lead ECG used throughout the world was introduced. This 12-lead ECG is so-called as it examines the electrical impulses and activities within the human heart 12 viewpoints (National Heart, Lung and Blood Institute, 2001).

There are three ECG standard leads I, II, and III. Lead I connect the electrodes on the right and left arms, with the left arm being positive (+). Lead II connects the electrodes on the right arm and left leg, with the left leg being positive (+). Lead III connects the electrodes on the left arm and left leg, with the left-leg being positive (+) once more (Ashley & Niebauer, 2004).

Chest Electrode Placement

The following are Azubuike's six locations of Chest Electrode Placement, as identified by Azubuike and Amechi (2011): V1 - Fourth intercostals space towards the right of the chest bone (sternum); V2 - Fourth intercostals space towards the left middle chest bone (sternum); V3 - Directly between V2 and V4; V4 - 5th intercostals space at mid clavicular line; V5 - Level with V4 at left anterior axillary line; and V6 - Level with V5 at left mid-axillary line (directly beneath the middle part of the armpit).

ECG Leads Views of the human heart

Azubuike and Amechi (2011) outline three ways ECG leads – views of the human heart can be seen: V1 and V2 are on the ventricle by the right (right ventricle), V3 and V4 are on the spetum/ventricle by the left (left ventricle)s, and V5 and V6 are on the anterior/lateral ventricle by the left (left ventricle)s.

ECG and the human heart Function

The human heart normally beats between 60 and 100 times per minute, with normal variations. For instance, athletes at rest have a slower heart rate than most people. This rate is by a small collection of specialized heart cells called the sinoatrial node (SA) or sinus node. The sinus node is the human heart's natural pacemaker and is located in the atrium by the right (right atrium). It is automatic which means it discharge all by itself without the control of the brain (Brose et al., 2002). Two (2) things will happen with each respective discharge: (1) the left and atrium by the right (right atrium) will contract as two electrical impulses/signals travel through the atria to reach the area of the human heart known as the atrioventricular (AV) node, which is between the left and ventricle by the right (right ventricle). The AV node acts as a relay point for electrical impulses to travel farther. An

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electrical wave goes from the AV node to the ventricles, contracts in response and results in the pumping of blood. The usual time between the atria and ventricles contracting is 0.12 to 0.20 seconds (Azubuike & Amechi, 2011). The physical transit of blood through the atrium to the ventricles is properly timed by this delay. Intervals that are shorter or longer than this suggests potential issues. Whenever the cardiac muscle cells found in the right and atrium by the left (left atrium) as well as those of the left and ventricle by the right (right ventricle) contract, the ECG picks this signal and records them as an indication of the human heart's electrical activities and impulses. The contractions of the atria (including right and left) appear as a P wave. The right and left ventricular contractions to appear as a series of three waves, Q-R-S, which is known as the QRS complex. The T wave is the 3rd and final common wave in an ECG. Whenever the ventricles are recharging for another contraction, electrical activity is created (repolarising). When seen from several anatomic-electric views (leads), the electrical impulse results in P, QRS, and T waves of varying sizes and shapes, which can reveal a wide variety of abnormalities in both the electrical transport system and the muscular tissue of the human heart's four pumping chambers (See Figure 1).

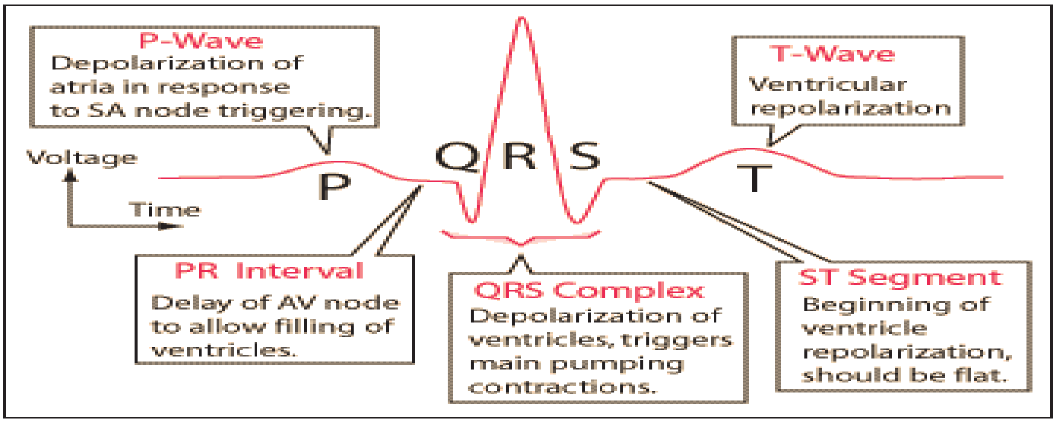

Fig 1: Diagram of PDRST Wave (Source: Taji, 2013)
Note: The characters P, Q, R, S, and T are not acronyms for real words, but were picked for their central location in the alphabet long ago.

ECG Interpretation
The piece of paper (graph) used for ECG is regulated to operate at 25mm/second, and the top and bottom are indicated at 1-second interval. The duration of each electrical impulse/event is correlated with its length of time on the horizontal axis. On the horizontal axis, each little block (marked by lighter lines) equals 0.04 seconds. A huge block is made up of five little blocks (represented by thick lines) and represents 0.20 seconds. Trying to count the blocks from the start to the finish of a segment, waveform, or interval determines the duration of the waveform, segment, or interval. According to Azubuike and Amechi (2011), the amount of time it takes for an electric signal from the sinoatrial (SA) node to spread all through the atrial musculature is represented by the P-wave. The p-wave is located before the QRS complex. The height of the amplitude must not surpass 2 to 2.5mm, and the duration should be between 0.06 and 0.11 seconds.

The **P-R interval** is the amount of time (usually in seconds) it takes for an electrical impulse within the human heart to go from the left and atrium by the right (right atrium) to the Purkinje fibres via the AV node, a bundle of His, and bundle branches. With a duration of 0.12 to 0.20 seconds, the P-R interval stretches from the QRS complex.

The depolarization of the ventricles is represented by the **QRS Complex**. The QRS complex is made up of three waves: a Q wave, an R wave, and an S wave. The Q wave always appears at the start of a deflection. The R wave is followed by the S wave, which is a negative deflection. The position is determined by the P-R interval. With a duration of fewer than 0.10 seconds, the amplitude standard values vary with sex and age.
The **Q-T interval** is the time it takes for the muscle of the human heart to contract or depolarize and then relax or repolarize. The position ranges from the start of the QRS complex to the termination of the T-wave (including the

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QRS complex, S-T segment, and T-wave), with duration varied with sex, heart rate, and age. The relaxing or repolarization of the heart's ventricles is represented by the **T-wave**. In rare situations, a U wave will appear after the T wave. With a position after the S-wave and S.T segment, the U wave characterizes the repolarization of the His-Purkinje fibres. It has a 5mm or less amplitude in conventional Leads I, II, and III, and a 10mm or less amplitude in pericardial Leads V1-V6, with no known period. The S-T Segment marks the conclusion of ventricular contraction (depolarization) and the start of ventricular relaxation (repolarization). The location is usually measured from the finish of the S wave to the start of the T wave, but the duration is not.

Expectations during an ECG Testing

ECG is not a very easy and uncomplicated procedure. During ECG examination, the testee lies down on a stretcher or a bed face up (supination). An ECG technician could be any medical practitioner trained to offer ECG which could be a doctor, nurse, or other professional. To start the ECG examination, the practitioner is required to place 6 small pads that are adhesive electrodes across the patient's chest from the lower part of the breast zone (the sternum) to an area below the left armpit (the axillary).

Other ECG pads must then be placed on the respective arms and legs. Through an insulated wire, all 10 ECG pads will be connected to the ECG machine/device. Once these connections are made, the ECG machine/device through an ECG sheet (a graph paper) produces a set of the ECG results in form of the P-QRS-T waves. This is recorded and analyzed from every 12 points of view. Six of these ECG points of view (PoV) are the location of the six (6) ECG pads placed across the chest and are termed V1, V2, V3, V4, V5, and V6. The other viewpoints are made up of different combinations of arm and leg pads. These are designated by the letters I, II, III, aVR, aVL, and aVF. All of these 12 views produce waves that may be interpreted to offer significant information about how your heart is working. A supplemental rhythm strip may be taken in addition to the 12-lead ECG. This is simply one point of view, but it is a useful tool for observing significant changes over an extended time.

In a standard 12-lead ECG, some changes may be difficult to make out, observe or interpret and sometimes very difficult to even detect in some of the heartbeats recorded. This is significantly relevant when the human heart at an abnormal rate (either slower or faster than its normal baseline heart rate). Sometimes, medical conditions that may not directly affect the heart, as well as some drugs (particularly in overdosed conditions) can impede the function of an otherwise healthy heart in ways that could impact ECG results when the heart is subjected to some diagnostic procedures. Some people with heart rhythm disorder (arrhythmia) or coronary heart disease have symptoms that come and go. These symptoms may include brief chest pain or (angina), palpitations, dizziness, or weakness.

Electrocardiogram and Exercise Setting

Heart disorders can generate a wide range of symptoms, and without an electrocardiogram (ECG), it can be difficult to establish if these clinical manifestations are a result of heart disease or are just a sign of one. An ECG will usually be performed unless such symptoms are accounted for by disease, accident, or condition that does not affect the human heart. An electrocardiogram (EKG or ECG) is made or done to help the exercise scientist to:

1. Check the human heart's electrical activity
2. Determine the source of unexplained chest discomfort, which might be the result of a heart attack, pericarditis (inflammation of the sac around the human heart), or angina.
3. Determine the source of heart disease symptoms like shortness of breath, lightheadedness, fainting, or accelerated, irregular heartbeats (palpitations).
4. Examine how effectively recommended drugs or exercises are functioning, as well as whether they are generating heart-related adverse effects.
5. Determine whether the borders of the chambers of the human heart are excessively thick (hypertrophied)
6. Examine the effectiveness of mechanical devices placed in the human heart, such as pacemakers, in maintaining a normal heartbeat.
7. If other diseases or conditions, including high blood pressure (HBP), hyperlipidemia, diabetes, cigarette smoking, or family background of early heart disease, are present, check the human heart's health.

Azubuike and Amechi (2011) outlined the following symptoms that could immediately pose the need for an electrocardiogram: difficulty breathing, nausea, frailty, palpitation (anomalous heartbeats or rapid beating heartbeats or greater consciousness of one's heartbeats, anxiousness, belly pain, and temporary loss of consciousness (fainting) are all symptoms of angina (syncope). ECG frequently discloses an issue or disorders

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that are not predominantly cardiac in origins, such as persons who have taken an excessive amount of certain medicines (such as antidepressants; cocaine or amphetamines) or individuals who have electrolyte imbalances (particularly potassium). During general anaesthesia surgery, an ECG is utilized to identify any silent cardiac conditions that may worsen as a result of the stress of surgery and anaesthesia.

People irrespective of their age and who work in jobs that put a strain on the human heart (such as professional coaches, athletes, or firefighters) or that need public safety (such as commercial aircraft pilots, railway conductors, and bus drivers) must have an ECG. An ECG test should be performed on anybody above the age of 40. ECG is used as a diagnostic tool for detecting any heart issues as well as a baseline for future ECG comparisons. Those with coronary heart disease (CHD) should get an ECG test performed first. The lifestyle of an individual is a good indicator of whether an ECG test is required. Individuals who are obese, smoking, and are exposed to a very high level of stress factors are highly predisposed to Coronary Heart Disease (CHD). Therefore, such individuals with symptoms will require an ECG test. Further genetic factors can also put one at risk of CHD.

Many people seem to inherit a great chance of suffering from CHD from their parents. Consider a little, Peter's family has a history of heart trouble. His grandfather and father both died of heart attacks at a relatively early age. His older sister is receiving treatment for angina. Peter is significantly overweight and smokes 25 cigarettes a day. As an exercise physiologist, give three ways Peter could reduce his chances of suffering from coronary disease.

For exercise physiologists and other healthcare providers and promoters, the good news about CHD is that almost all risk factors can be controlled. For instance, one can eat a healthier diet, take more exercise, and, quit smoking. Even stress responds well to being healthy. People who have good health can respond better to stress than people who are overweight and unfit. For this reason, the expert recommends that the best way to survive a heart attack is not to have any of the risk factors in the first place. That means sticking to a healthy lifestyle.

Conclusion

The electric signals that govern the contraction of the cardiac muscles are plotted on an electrocardiogram (ECG). It's a diagnostic instrument that detects and captures the human heart's electrical activity in great detail, ranging from trivial to life-threatening, and the ability to interpret these data allows for the diagnosis of a variety of cardiac disorders.

Recommendations

Based on the review made so far, the following recommendations were deemed necessary:

1. People who took overdoes on some drugs (like an antidepressant, cocaine or amphetamines) people undergoing general anaesthesia surgery; people who are in an occupation that places stress on the primary cardiovascular organ - the human heart, as well as people older than age 40 need a baseline electrocardiogram ECG test done before problems develop.
2. Most important, an exercise stress test should be done especially when the result of the ECG is inconclusive to further give an insight into the result obtained earlier.

References

Atare, F.U., & Mong, E.U. (2006). *Concepts of Exercise Physiology*. EBSU Press.

Ashley, E.A., & Niebauer, J. (2004). *Cardiology Explained.* Conquering the ECG. *https://www.ncbi.nlm.nih.gov/books/NBK2214/*

Azubuike, C. U. & Amechi, C. O. (2011). *Understanding the electrocardiogram as a diagnostic tool: Uses and Benefits; Contemporary Issues in Sports (ed).* Ednaway activities.

Brose, J. A., Auseon, J. C., & Waksman, D. (2002). *Guide to interpretation, white coat pocket Guide series (ed).* Ohio University Press.

Gordon, B.J. (2013). *Anatomy & physiology*. Gordon's Press.

Lindskog, C., Linné, J., Fagerberg, L., Hallström, B.M., Sundberg, C.J., Lindholm, M., Huss, M., Kampf, C., & Choi, H. (2015). "The human cardiac and skeletal muscle proteomes defined by transcriptomics and antibody-based profiling". *BMC Genomics*, 16, 475.

Longo, D., Fauci, A., Kasper, D., Hauser, S., Jameson, J., & Loscalzo, J. (2011). *Harrison's Principles of Internal Medicine* (18 ed.). McGraw-Hill Professional.

Moore, K.L., Dalley, A.F., & Agur, A.M. R. (2009). *Clinically Oriented Anatomy*. Wolters Kluwel Health/Lippincott Williams & Wilkins.

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National Heart, Lung and Blood Institute (NHLBI) (2001). *International Guidelines for the Diagnosis, Management and Treatment of Heart Diseases.* NHLBI Press.

Taji, B. (2013). Reconstruction of ECG Signals Acquired with Conductive Textile Eletrodes. Semantics Scholar. *https://www.semanticscholar.org/paper/Reconstruction-of-ECG-Signals-Acquired-with-Textile-Taji/8490b9994558915d820bfb37ee402a23dc94ee58.*

Tuma, R. R., & Houser, S. (1982). *Cardiovascular Physiology Lecture Note*. University School of Medicine.

Wagner, G. S., Marriott, H. J., & Marriott, M. (2002). *Marriott's Practical Electrocardiography.* William and Wilkins.

Walsh, M., Desouze, J., Scourfield, P., Stephens, P. & Price, G. (2000). *Advanced Vocational Health and Social Care.* Collins Press.

Zao, P., Stabler, T., Smith, L., Peterson, G., Gibson, M., & Zaretti, N. (2006). *PhysioEx for A & P Laboratory stimulations in Physiology.* Benjamin & Cummings Press.

Cite this article as:
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