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Effect of Oscillating Magnetic Field on Heart Parameters of Malaria Parasite Infected Wistar Rats

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Annotation

Studies on the effect of oscillating magnetic field (OSMF) have shown that this field can be used as an alternative therapy to malaria. Still, its impact on the heart parameters is yet to be ascertained. The influence of OSMF was investigated on Heart triglycerides, high-density lipoprotein, and total cholesterol of three weeks old Plasmodium falciparum-infected Wistar rats. Sixty-two Wistar rats were obtained, out of which Forty-nine were infected with plasmodium falciparum, equally divided into seven experimental groups (A, B, C, D, E, G & H) containing seven rats each. Groups A to E were exposed to 10mT, 15mT, 20mT, 30mT, and 40mT, respectively, for seven consecutive days. Group G was not exposed to OSMF but treated with malaria drug, Artemether + Lumefantrine, while Group H was given no treatment for those seven days. Group F consists of non-infected rats, and were exposed to 40mT OSMF, while Group I was used as control. The results obtained showed that the parasite count of groups exposed to OSMF considerably decreased ($p<0.05$) on the 5th-day compared to Group H. Similarly, the level of inhibition of the parasitemia count in the group treated with conventional antimalaria drug reduced significantly ($p<0.05$) on day 5 when they were compared to the initial parasite load on day 0. Results also showed considerable changes in the heart parameters of the experimental groups. This concludes that OSMF can be applied in treating malaria but alters the level of triglycerides, high-density lipoprotein, and total cholesterol in the heart of a living Wistar rat.

Key words: *Oscillating magnetic field, Plasmodium falciparum, Heart Parameters, Triglycerides, High-density lipoprotein, Total Cholesterol, Parasitemia Count.*

1. INTRODUCTION

A Series of experiments has been conducted to find an alternative therapy for the treatment of malaria due to the opposing power of the malaria parasite (plasmodium) to antimalaria drugs. Studies have shown that chemotherapy and combination therapy (administration of different malaria drugs spontaneously) are the main modes of treating malaria. Sadly, there are setbacks in treating malaria in most underdeveloped countries. The reason is due to many adulterated drugs readily available in medical stores and markets. Moreover, humans' continued use of unadulterated antimalaria drugs has built up high plasmodium resistance [1,2].

According to WHO, about 241 million worldwide cases of malaria were estimated in 2020 [3]. Moreover, African Region shares a more significant percentage of the global malaria burden. About 627 000 malaria-related deaths were recorded. Likewise, children under the age of 5 accounted for an estimated 80% of the death cases in Africa [3]. In October 2021, the WHO recommended the wide use of the malaria vaccine (RTS, S/AS01). The vaccine was endorsed for general use among children, and it has been shown to reduce severe malaria significantly [3]. Additionally, Artemisinin-

based combination therapy (ACT) has been recommended by WHO as the best treatment available for malaria. The main objective of ACT is to ensure fast and total removal of Plasmodium parasites from a patient's bloodstream, thereby preventing a simple malaria case from developing into a severe one or probably death.

Nevertheless, there has been a massive increase in malaria parasite resistance (plasmodium falciparum) to antimalaria drugs recently. This phenomenon has become a significant threat to the effort of WHO in controlling malaria globally [4]. About a hundred and thirty-two billion naira was estimated to have been spent on malaria treatment and prevention per year [5]. The high amount of money spent combating malaria and the opposing power of malaria parasites to antimalarial drugs has increased the insistence on a novel strategy for eliminating malaria parasites. Therefore, this research proposes the use of an oscillating magnetic field (OSMF) as an alternative treatment for malaria. Several experimental studies on oscillating magnetic field antimalaria therapy have shown that malaria parasites leave some Hemes undestroyed in the erythrocyte (also known as red blood cell) after feeding on the globin part of the hemoglobin as a source of nutrient [6,7]. These free Hemes produce a toxic environment for the malaria parasites, in which the parasites always find a way to modify by binding the Hemes into a polymer (in the form of a tiny bar magnet), known as Hemozoins [8,9,10].

Hemozoin is a toxic substance that causes chill and recurring fever in the host. The breaking down of the Hemozoins into Hemes is achievable by the oscillating magnetic field process [11,12]. The outcome of OSMF on Plasmodium falciparum-infected Wistar rats as an antimalaria therapy was evaluated in this study. We also assess the impact or side effects of applying OSMF on the heart parameters (triglycerides, high-density lipoprotein, and total cholesterol) of the Wistar rats.

2. EXPERIMENTAL

2.1 Materials and Methodology

The following samples were provided for this research:

A solenoid (constructed from a soft cylindrical metal sheet frame of 7cm radius, wounded with 220 turns of 18 standard wire gauge (SWG) coil conductor with a thickness of 102.5 mm and inner radius of 750 mm at room temperature); 30 volts transformer, used to get an alternating current of 6 Amps output for powering the solenoid; a plastic cage (situated in the Animal Laboratory, Adekunle Ajasin University), and cereal pellets for feeding the rats (Figure 1). Some of the chemicals used for biochemical analysis are; thiobarbituric acid, sodium acetate trihydrate, and triethanolamine hydrochloride. They were all purchased from Store. All other reagents were obtained from the University of Lagos, Lagos, Nigeria, and were analytical grade. The thiobarbituric solution (TBARS) was prepared by dissolving 0.67g of the solution in 100 ml of deionized water. It was then diluted with glacial acetic acid in a ratio of 1:1. Germless deionized water was used throughout the study. A Microplate Test Reader machine in the Animal Laboratory of Adekunle Ajasin University, Akungba-Akoko, was used during biochemical test analysis.

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Figure 1: Solenoid for generating an oscillating magnetic field (OSMF)

2.2 Animal

For this research, sixty-two (62) Wistar rats were procured from the University of Ibadan's Department of Parasitology. Out of these, forty-two (42) were infected with plasmodium falciparum, equally divided into seven experimental groups (A, B, C. D, E, G & H) containing seven rats each after seven days of acclimatization. The rest of the non-parasite-infected rats were divided into F and I groups, respectively. The animals were treated per the Rules and Regulations laid down by the National Institute of Health concerning Laboratory Care (National Institutes of Health Publication, 1985).

Figure 2: Experimental Wistar rats in a normoxic room temperature

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2.3. Experimental Procedures

Forty-nine (49) Wistar rats were infected with plasmodium falciparum from the Sixty-two (62) Wistar rats procured from the University of Ibadan's Department of Parasitology. They were equally grouped into seven (A, B, C. D, E, G & H) containing seven rats each after seven days of acclimatization. Group A rats were exposed to 10mT, 15mT for Group B, 20mT for Group C, 30mT for Group D, and 40mT for Group E. In contrast, group G rats were treated with malaria drug, Artemether + Lumefantrine (POSITIVE CONTROL), and those in Group H were given no treatment (NEGATIVE CONTROL) for seven consecutive days.

The rest of the non-parasite-infected rats were separated into groups F and group I. The rats in group F were exposed to 40mT OSMF (TREATMENT CONTROL), while group I was used as NORMAL CONTROL (rats without parasites and not exposed to OSMF). The exposure period (6 hours daily) to OSMF was the same for all the groups exposed, and the rats were fed with cereal pellets and water regularly. Three rats from group A (treated with 10mT OSMF) were too weak and died on the fourth day of exposure.

Figure 3: Experimental rats during exposure to Oscillating magnetic field

Blood samples (about 0.4 ml) were collected from the tail of the experimental rats into slides daily and taken to the Animal Laboratory, Adekunle Ajasin University, for parasite growth investigation for those seven days. The slides were carefully viewed under a high resolving effect microscope. After exposure to OSMF on the last day of the experiment, the Wistar rats were sacrificed, and a heart biopsy was carried out. The rats' hearts were excised and rinsed in saline to remove excess blood. After rinsing, the rats' hearts were grounded and frozen at about -80°C before biochemical tests analysis. Biochemical tests on the heart parameters (high-density lipoprotein (HDL), total cholesterol (Chol), and triglycerides (Trig)) of the rats were analyzed. All biochemical tests were done in the Animal Laboratory of Adekunle Ajasin University, Akungba-Akoko.

3. RESULTS AND DISCUSSION

Table 1 shows the impact of OSMF on parasite density in parasite-infected rats. The parasitic inhibition was estimated by likening the differences in parasite density on day 0 to the last day of treatment. All the obtained values were reported as mean.

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Table 1. Estimated values for Parasite density in experimental rats for the first five days

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5
OSMF 10(+)	1824±152[a]	1752±160[a]	1658±152[a]	1605±120[a]	1495±182[ab]	1477±212[ab]
OSMF 15(+)	1744±127[a]	1638±138[a]	1569±127[a]	1430±112[ab]	1395±38[ab]	1360±96[b]
OSMF 20(+)	2022±168[a]	1900±156[a]	1779±168[a]	1658±108[ab]	1577±76[b]	1516±86[b]
OSMF 30(+)	1944±212[a]	1788±168[a]	1681±212[ab]	1584±136[ab]	1496±104[b]	1438±126[b]
OSMF 40(+)	1884±196[a]	1676±128[ab]	1563±196[ab]	1469±102[b]	1450±114[b]	1337±58[b]
POS CNTRL(+)	1784±182[a]	1392±98[b]	941±182[c]	446±32[d]	356±44[e]	249±22[f]
NEG CNTRL(-)	1964±232[a]	2022±206[a]	2058±232[a]	2072±184[a]	2081±128[a]	2121±128[a]

*The above-derived values are recorded as Mean ± Standard Error Mean(SEM)

**The derived values of Day 1 - 5 were compared with Day 0, which was taken before the treatment.

***Different notations on derived values across a row show the statistical difference of $p < 0.05$

Table 2. Percentage inhibition of parasites by the experimental rats in the first five days

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5
OSMF 10(+)	100.00	96.05	90.90	87.99	81.96	80.98
OSMF 15(+)	100.00	93.92	89.97	82.00	79.99	77.98
OSMF 20(+)	100.00	93.97	87.98	82.00	77.99	74.98
OSMF 30(+)	100.00	91.98	86.47	81.48	76.95	73.97
OSMF 40(+)	100.00	88.96	82.96	77.97	76.96	70.97
POS CNTRL(+)	100.00	78.03	52.75	25.00	19.96	13.96
NEG CNTRL(-)	100.00	102.95	104.79	105.50	105.96	107.99

*All the values are reported as a percentage.

**Day 0 parasite density was considered 100

From the estimated values in Table 1, the parasite density of the group treated with artemether-lumefantrine (POS CNTRL) reduced significantly on Day 5 (249±22[f]) when compared with the premier parasite density (1784±182[a]) on day 0. Nevertheless, the group of rats infected with malaria virus but not treated with either OSMF or antimalaria drug (NEG CNTRL) parasite density increased significantly on Day 5 (2121±128[a]) compared with Day 0 (1964±232[a]). A meaningful deduction ($p < 0.05$) was observed in the value of parasite density on Day 5 compared with the NEG CNTRL group among the groups exposed to an OSMF. Table 2 shows the percentage values of Table 1.

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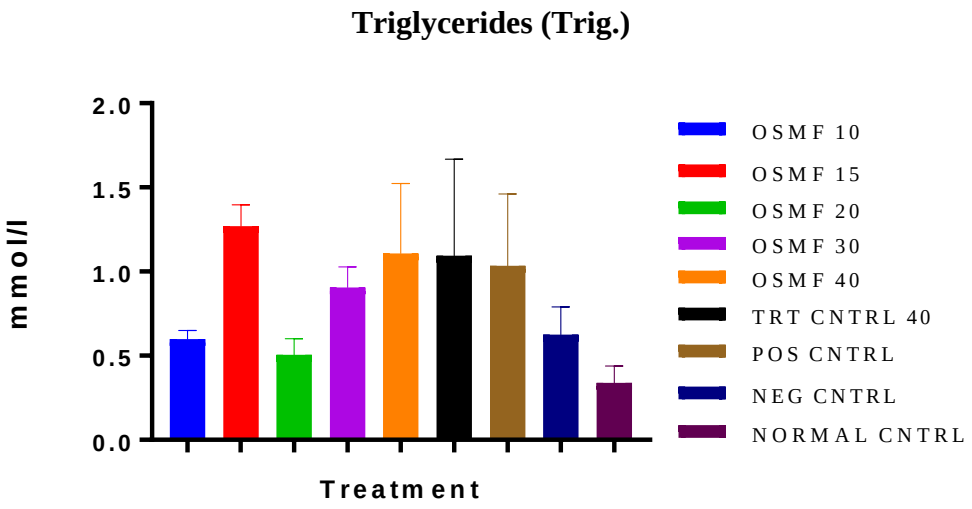

Figure 4: The data obtained from the effect of OSMF (50HZ, 10mT, 15mT, 20mT, 30mT & 40mT, 6h/day) on the heart Triglycerides of Wistar rats after seven days of treatment

The chart in Figure. 4 shows the disparity in the impact of oscillating magnetic field (OSMF) on the heart Triglycerides in experimental rats infected with Plasmodium falciparum and control rats that were not infected with the virus. Standard error was used to measure the level of disparity in values. Error bars represent standard deviation (STD), used to determine how dispersed the obtained values were from the mean values from each group during test analysis. In Figure. 4, the level of triglycerides of the groups exposed to 10mT, 20mT, and 30mT OSMF decreases significantly compared to those treated with the antimalaria drug (POS CNTRL). However, no significant discrepancies in the hearts' triglycerides levels of groups exposed to 40mT OSMF, the group of non-parasite-infected rats exposed to 40mT OSMF (TRT CONTROL), and those in POS CNTRL. Triglycerides exist in the body as fat [13]. A high triglyceride level in a living body puts the body at risk of coronary artery diseases [13]. Studies have shown that when the heart Triglycerides level goes too high than the HDL level, it puts the host at risk of heart attack or stroke [13]. Results from Figure.4 show that 40mT OSMF used as treatment control (TRT CNTRL) has no significant difference in the heart triglycerides compared to the effect of applying artemether-lumefantrine as antimalaria therapy.

High-Density Lipoprotein (HDL)

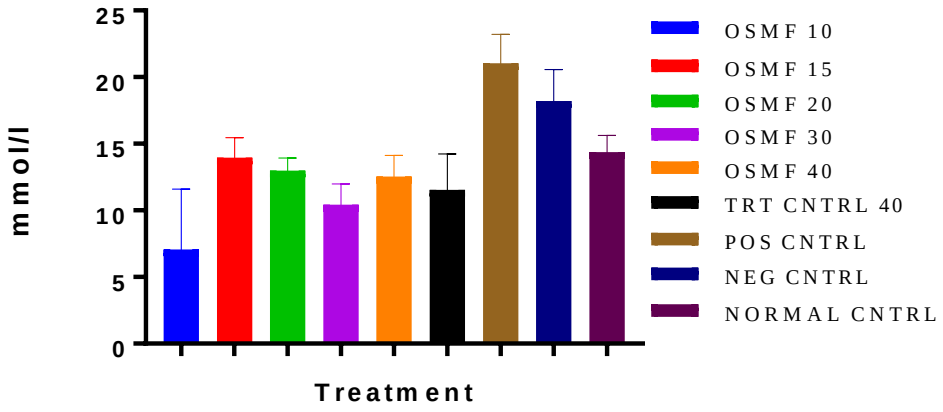

Figure 5: The data obtained from the effect of OSMF (50HZ, 10mT, 15mT, 20mT, 30mT & 40mT, 6h/day) on the heart HDL of Wistar rats after seven days of treatment

Figure. 5 shows the level of disparity in high-density Lipoprotein (HDL) in the heart of the experimental and control rats. High-Density Lipoprotein, also known as HDL, means "Good Cholesterol." HDL transfers all other body cholesterol back to the Liver for removal from the body [14]. The results observed in Figure. 5 indicate that HDL in all animals exposed to OSMF reduces significantly compared to the group of rats treated with the antimalaria drug. There was no significant difference in the amount of high-density lipoprotein (HDL) between the group of rats that were neither exposed nor infected with the virus (NORMAL CNTRL) and the group of rats with malaria parasite exposed to OSMF of 15mT OSMF. Since HDL is known as good cholesterol in the body, a high amount of HDL helps protect the heart against diseases, whereas a low HDL level puts the heart at risk of getting infected [15,16].

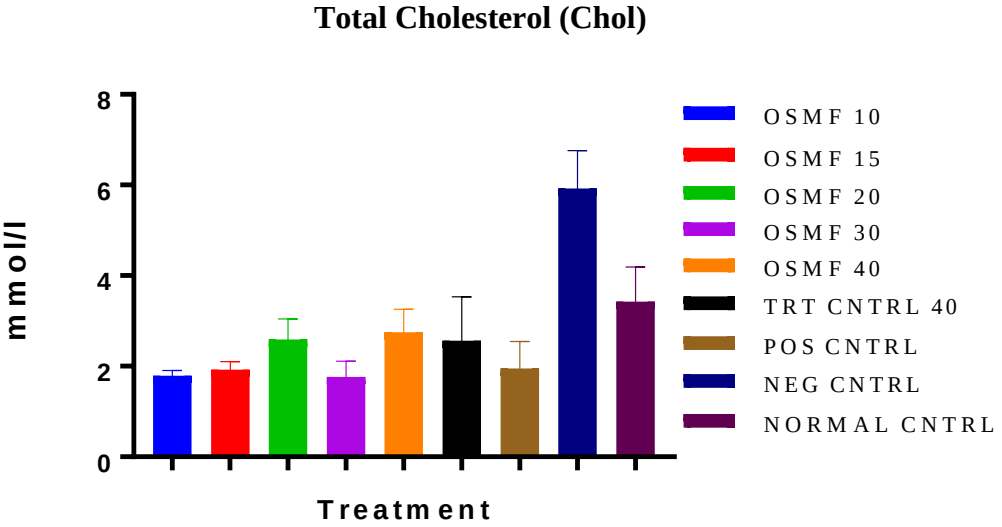

Figure 6: The data obtained from the effect of OSMF (50HZ, 10mT, 15mT, 20mT, 30mT & 40mT, 6h/day) on the Total heart Cholesterol of Wistar rats

The disparity in total cholesterol (Chol) of the heart in experimental and control rats is given in Figure. 6. The results showed a significant decrease in total cholesterol in the heart of the rats treated with the oscillating magnetic field (OSMF) compared to the NORMAL control rats (rats that were neither infected nor exposed to OSMF). However, the heart's total cholesterol of rats in the NEGATIVE CONTROL group (rats infected with malaria virus but not given any treatment) increases significantly. This result showed that oscillating magnetic has a positive impact on the heart by stepping down its total cholesterol, as was observed in Figure 6. Excess amounts of cholesterol can lead to coronary artery disease [16, 17]. The outcomes of this research are similar to those obtained by Bellossi A et al., 1992, 1996, 1998 and Huang et al., 1996, where the rats in the study were exposed to pulsed and alternating magnetic fields, respectively [18,19,20]. These results align with the hypothesis that a biological system's physiological equilibrium is critical to responding to possibly efficient alternating magnetic field stimuli [21,22]. For further studies, it is vital to establish the extent of the organ damage that may have occurred.

4. CONCLUSION

Malaria is spread through mosquito bites (Anopheles). Plasmodium sporozoites attack the host and grow into hundreds of merozoites, causing symptomatic malaria. This research was carried out to check the effects of oscillating magnetic field (OSMF) antimalarial therapy in treating plasmodium falciparum-infected Wistar rats. The combination of the unfavorable impact of malaria parasite activity and OSMF on the host, focusing on determining the level of disturbance in the heart parameters (Trig, Chol & HDL), is the key to this study. The heart is an essential organ in the body system, and the therapeutic effect of OSMF implies an alternative malaria antidote to the conventional malarial medication. According to this study, an oscillating magnetic field (OSMF) is

an efficient antimalaria therapy but causes some heart parameters (Triglycerides, High-density lipoprotein, and Total cholesterol) alterations. According to the findings, the experimental rats' modifications in the heart's total cholesterol, High-density lipoprotein, and triglycerides showed that the oscillating magnetic fields influenced the hormonal systems directly or indirectly.

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