COMPREHENSIVE REPORT ON THE RESEARCH GRANT PROJECT TITLED: "NEUROENDOCRINE AND METABOLIC STUDIES OF MOBILE PHONE RADIATION"

You may recall that the award ceremony of the 2018 research grant awarded to us by your Organization (Nigerian Communications Commission - NCC) took place in June, 2019 at the NCC Headquarters in Abuja. Below is the report of the first phase of the work. I want to inform your good office that the research has gone far:

1.0 STAGE 1 DELIVERABLES

Stage **1** of the deliverables of the Research as contained in the award letter (as attached herewith) has been achieved as follows:

A) Stage 1: ***Construction and validation of the Neurobehavioral models*** was done

i. **Beam walk Test Apparatus:** A model for the assessment of Motor Coordination ***(human movement):*** Mice were trained to walk from a start platform along a ruler (80 cm long, 3 cm wide) elevated 30 cm above the bench by metal supports to a goal box (enclosed hamster house). Three trials were performed for each mouse, and were designed such that the mice tested would be aware that there was a goal box that could be reached. A ruler was used because the mice found this easy to cross and, at the same time, it induced minimum anxiety. The mice were placed on the beam at one end and allowed to walk to the goal box. Mice that fell were returned to the position they fell from, with a maximum time of 60 s allowed on the beam. The measurements taken were latency and foot slips (Stanley *et al*., 2005).

ii. **Hang test Apparatus:** A model that tests muscle strength ***(human movement):*** Hang test model is a test of muscle strength using all four limbs, it is an inverted screen with 43 cm squares of wire mesh consisting of 12 mm squares if 1 mm diameter wire. It is surrounded by a 4 cm deep wooden beading (Deacon, 2013). The test begins when the animal is place on the top of the cage which is then inverted and suspended above the home cage, the latency to when the animal falls is recorded. The test is performed two times and the average is taken.

iii. **Morris Water Maze Apparatus:** A wet maze for the assessment of learning and memory ***(cognition/memory retention)*.**

iv. **Elevated Plus Maze (EPM):** for the assessment of long-term memory ***(cognition/memory retention)*.**

v. **Barnes's Maze Apparatus:** A dry maze for the assessment of learning and memory ***(cognition/memory retention)*.**

vi. **Open Field Apparatus:** for the assessment novel objects ***(Novel object Recognition Test for memory retention)***

vii. **Hole Board:** A model for the assessment of anxiety-like behavior

viii. **Hotplate and Analgesiometer:** Models for the assessment of pain perception

ix. **Tail Suspension Test (TST) Suspension Box:** Model for the assessment of depressive-like behaviour

2.0 STAGES 2 AND 3 DELIVERABLES

Stages **2 and 3** of the deliverables of the Research respectively as contained in the award letter have been achieved and the summary of the findings are as follows:

1.0 Control versus Experimental Group Animals

All the following behavioral studies that were conducted have control groups. These control group animals have not been subjected to any of the exposures of the experimental animals such as vibration, ring tones, silence or combination of any of the exposures. Moreso, these control animals were kept in a different laboratory far from the experimental animals to avoid them being subjected to the mobile phone radiations. The animals were only tested on the experimental/behavioral paradigms (beam walk apparatus, elevated plus maze, etc.) together with the experimental animals after finishing with their exposure. This has made the control animals of each neurobehavioral to be free from the experimental exposures. The results of these control animals therefore served as baseline data for the behaviors of all the experimental animals.

2.0 Cognitive behavior

In Morris water maze model of learning and memory, on the day 1 of the acquisition phase as shown on **table 2.1**, there was no significant difference ($p>0.05$) in latency to locate the escape platform observed in all the groups. However, on day 2, the latency to locate the escape platform in vibration mode and ring and vibration mode were significantly increased when compared to control group and silent mode ($p\leq 0.05$). The vibration mode has a significantly higher latency when compared to switched off and ringtone mode ($p\leq 0.05$). On day 3, the latency in ringtone mode was significantly higher when compared to control, silent mode as well as the vibration mode ($p\leq 0.05$). In **table 2.2**, there was no significant

difference in latency to locate the target quadrant and number of plat form crossing between all the groups (p>0.05), during the probe day of Morris water maze model of learning and memory.

The result for novel object recognition test as shown in **table 2.3**, there was a significant increase in both discrimination index and percentage preference ($p \leq 0.05$), in the ringtone mode when compared to the control, switch off as well as silent modes. The vibration mode has a higher discrimination index and percentage preference when compared to ring and vibration mode ($p \leq 0.05$).

In the trial phase of Barnes maze model as shown in **table 2.4**, on the day 1 of the trail phase, there was no significant difference (p>0.05) in the latency to locate the drop box between all the experimental groups. On day 2, there was a significant reduction in the latency of switched off mode and vibration mode when compared to control ($p \leq 0.05$). There was also a significant increase in the latency to locate the drop box in silent mode, ringtone mode and ring and vibration mode when compared to switched off mode ($p \leq 0.05$). On day 3 of the trial phase, there was a significant increase in the latency of silent mode, ringtone mode and ring and vibration mode when compared to both control and switched off mode. In addition, the ring and vibration mode is significantly higher than the vibration mode ($p \leq 0.05$). on the probe day, as shown in **figure 2.1**, there was a significant increase in the number of incorrect head dips in the ringtone mode when compared to both the control and switched off groups ($p \leq 0.05$).

In elevated plus maze model as shown in **table 2.5**, during the retention phase, there was a significant increase in the latency to locate the closed arms of the maze in the vibration mode when compared to both the control and switched off groups ($p \leq 0.05$). However, there was a significant decrease in the latency in the ring and vibration mode when compared to the silent mode ($p \leq 0.05$).

Table 2.1: Effect of Exposure to Mobile Phone Radiation on Latency to locate escape platform in mice during the Acquisition Phase of Morris water maze

GROUPS	DAY 1 (latency sec)	DAY 2 (latency sec)	DAY 3 (latency sec)
Control	98.25±10.63	123.50±9.50	31.75±2.56
Switch off	118±42.88	164.37±22.13	45.12±0.77
Silent	106.81±13.82	127.55±9.15	75.62±11.56
Vibration	59.00±12.79	282.50±43.70[abc]	38.75±6.27
Ring	108.50±19.29	156.56±12.34[d]	94.18±19.48[abd]
Vibration and Ring	76.50±19.55	235.50±16.74[ac]	78.00±10.79

Results are presented as Mean ± Standard error of mean (n = 10). Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode and c = significant difference ($p \leq 0.05$) when compared to Silent mode, d= significant difference ($p \leq 0.05$) when compared to vibration mode.

Table 2.2: Effect of Mobile Phone Radiation on Number of Entries into Target Quadrant, Number of Plat Form Crossing and Latency at Target Quadrant for the Probe Day in Mice in Morris Water Maze

Groups	Number of entries Into target Quadrant	Number of platform crossing	Time spent at target quadrant
Control	9.00±0.54	8.60±0.24	30.75±1.52
Switch off	8.75±0.48	8.00±0.83	32.25±3.74
Silent	15.40±4.71	13.20±14.22	37.00±4.21
Vibration	12.00±0.44	6.80±1.20	54.80±6.71
Ring	0.94±2.08	7.60±2.29	33.40±8.24
Ring and Vibration	14.50±2.72	15.40±4.54	37.60±9.70

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test.

Table 2.3: Effect of Mobile Phone Radiation on Discrimination Index (DI) and Percentage Preference (PP) in mice During Novel Object Recognition Test.

GROUPS	DI	PP
Control	0.21±0.03	21.50±3.79
Switch off	0.09±0.25	9.25±25.7
Silent	0.05±0.05	5.00±5.21
Vibration	0.30±0.30	30.25±11.83
Ring	0.83±0.83^{abc}	83.00±7.41^{abc}
Ring and Vibration	0.00±0.00^{d}	0.00±0.00^{d}

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode and c = significant difference ($p \leq 0.05$) when compared to Silent mode, d= significant difference ($p \leq 0.05$) when compared to vibration mode, DI= Discrimination Index, PP= Percentage Preference.

Table 2.4: Effect of Mobile Phone Radiation on Latency during Trial Phase for Barnes Maze in Mice.

GROUPS	DAY 1	DAY 2	DAY 3
	Latency(sec)	Latency(sec)	Latency(sec)
Control	300.00±0.00	300.00±0.00	24.50±3.50
Switch off mode	270.00±30.00	81.75±35.86$^{\mathbf{a}}$	36.50±4.97
Silent mode	283.25±11.79	266.75±23.57$^{\mathbf{b}}$	230.50±60.22$^{\mathbf{ab}}$
Vibration mode	300.00±0.00	153.00±16.98$^{\mathbf{a}}$	80.00±28.06
Ring mode	294.25±5.75	257.50±42.50$^{\mathbf{b}}$	209.50±62.28$^{\mathbf{ab}}$
Vibration and Ring mode	270.00±12.25	261.00±15.92$^{\mathbf{b}}$	291.75±5.89$^{\mathbf{abd}}$

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode and, d = significant difference ($p \leq 0.05$) when compared to vibration mode

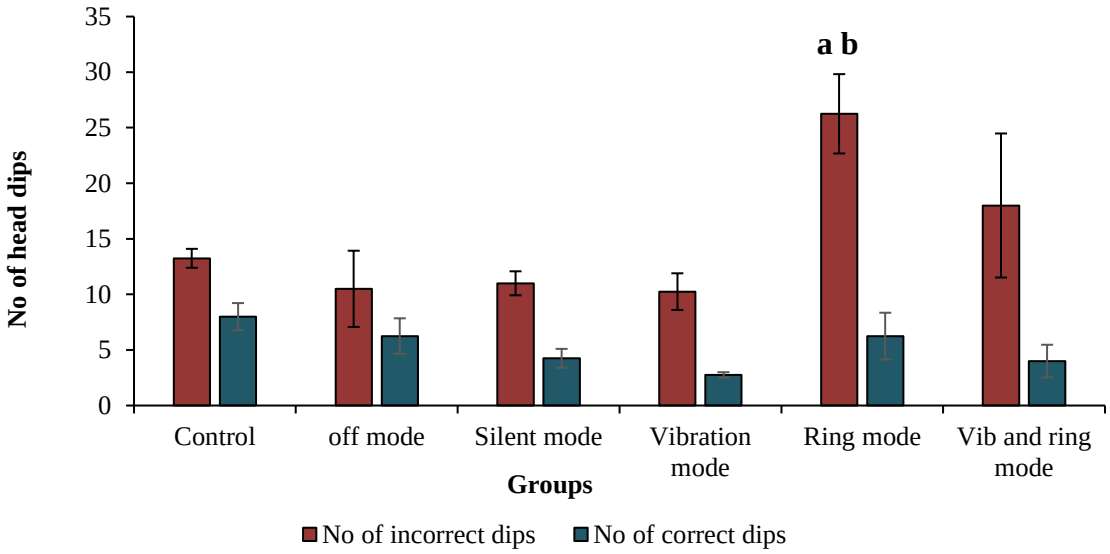

Figure 2.1: Effects of Mobile Phone Radiation on the Number of Head Dips in Barnes Maze on the Probe Day in Mice.

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode.

Table 2.5: Effect of Mobile Phone Radiation on Acquisition and Retention Phases of Elevated Plus Maze in Mice

Groups	Acquisition (sec)	Retention (sec)
Control	27.00±4.32	15.40±2.04
Off Mode	22.20±8.79	30.40±6.87
Silent Mode	20.40±2.66	21.40±2.93
Vibration Mode	55.00±13.51	59.20±13.77[ab]
Ring Mode	36.60±9.83	37.60±13.50
Vibration and Ring Mode	42.80±7.54	10.60±0.68[c]

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode and c = significant difference ($p \leq 0.05$) when compared to vibration mode.

3.0 Motor coordination

The result on the latency to reach the goal box in Beam walk assay as shown on **figure 3.1**, there was a significant increase in the latency in the switched off mode when compared to the control ($p \leq 0.05$). However, there was a significant reduction in latency in silent mode, ringtone mode, vibration mode and ring and vibration mode when compared to both control and switched off mode ($p \leq 0.05$). The result on the number of foot slip in Beam walk in **figure 3.2**, did not show any statistically significant difference in the number of foot slip in all the experimental groups ($p > 0.05$).

In Hang test as shown on **figure 3.3**, there was a significant reduction in the latency to lose grip in vibration mode and ring and vibration mode when compared to control, switched off mode, silent mode and ringtone mode ($p \leq 0.05$).

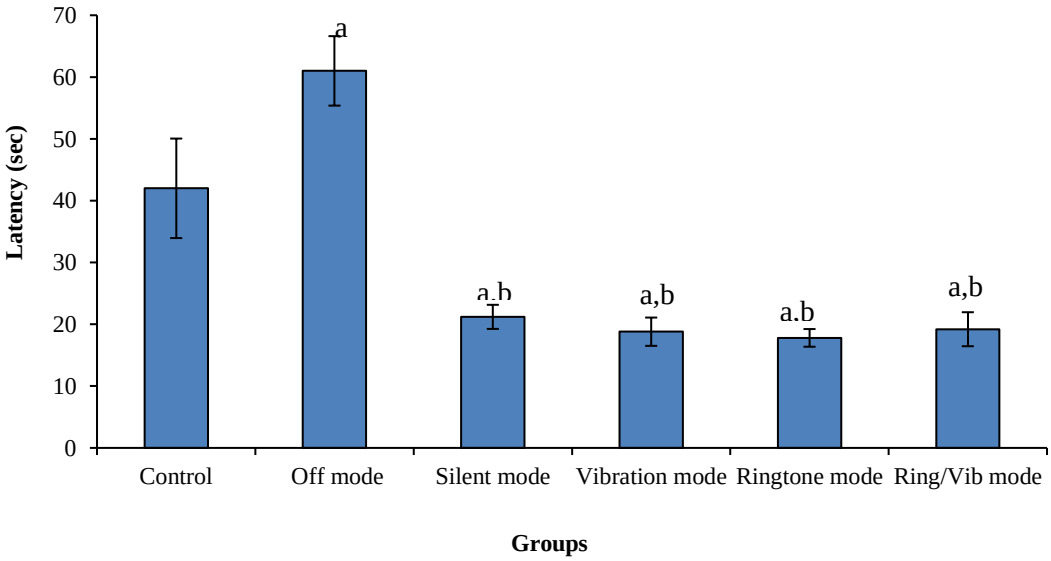

Figure 3.1: Effect of Mobile Phone Radiation on Latency in Beam Walk in Mice.

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode.

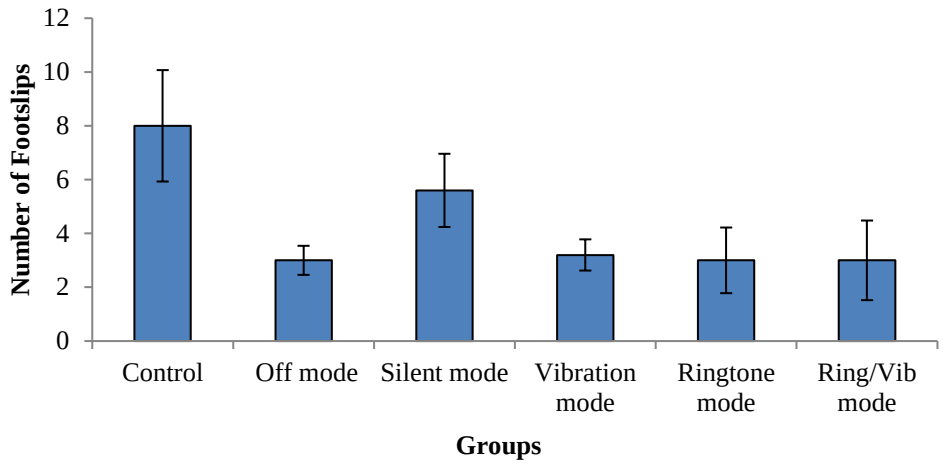

Figure 3.2: Effects of Mobile Phone Radiation on Number of Foot slips in Beam walk in Mice

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test.

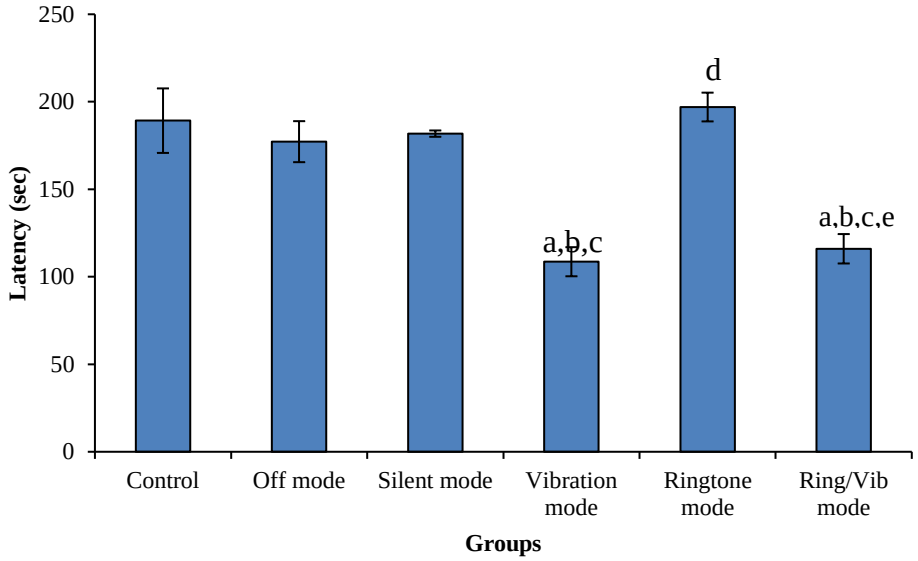

Figure 3.3: Effect of Mobile Radiation on Latency in Hang Test in Mice.

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode and c = significant difference ($p \leq 0.05$) when compared to Silent mode, d= significant difference ($p \leq 0.05$) when compared to vibration mode, e= significant difference ($p \leq 0.05$) when compared to ringtone mode

4.0 Anxiety-like behavior

The result on **Table 4.1** shows the result of the effect of exposure to mobile phone radiation on number of line crossing, center crossing, rearing, fecal and urine drops in mice. There was no statistically significant difference when these parameters were compared between all the groups ($p>0.05$).

In Hole board test as shown on **Table 4.2**, there was a significant increase in the number of head dips in vibration mode and ringtone mode when compared to the switched off mode. In addition, the ringtone mode has number of head dips that was also significantly higher when compared to the control ($p\leq 0.05$).

Table 4.1: Effect of Mobile Phone Radiation on Anxiety-like Behavior in Open Field Test Model in Mice

Groups	Mean Number of Line Crossing	Mean Number of Center Crossing	Mean Number of Rearing	Mean Number of Defecation Drops	Mean Number of Urination Drops
Control	40.80±15.82	0.00±0.00	12.60±4.01	1.40±0.40	0.40±0.40
Off mode	56.20±19.27	0.20±0.20	22.00±6.15	1.60±0.68	0.20±0.20
Silent mode	48.60±11.89	0.00±0.00	17.40±4.60	1.60±0.60	0.60±0.40
Vibration mode	35.40±13.18	0.20±0.20	14.20±4.83	2.40±0.51	0.20±0.20
Ring mode	40.20±3.95	0.00±0.00	11.80±0.80	2.80±0.49	0.20±0.20
Vibration and Ring mode	57.00±11.66	0.00±0.00	19.20±3.24	2.40±0.68	1.40±1.17

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test.

Table 4.2: Effect of Mobile Phone Radiation on Number of Head Dips in Hole Board Test in Mice

Groups	Mean Number of Head Dips
Control	20.00±2.30
Switch off mode	14.60±3.54
Silent mode	26.00±5.63
Vibration mode	33.80±5.80[b]
Ring mode	41.20±1.56[ab]
Vibration and Ring mode	25.40±3.57

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode

5.0 Depression-like behavior

The result on the duration of immobility time in mice exposed to mobile phone radiation using forced swim test as shown in **figure 5.1**, did not show any statistically significant difference in the immobility time in all the groups ($p > 0.05$).

In tail suspension test model however, there was a significant increase in the immobility time in the ringtone mode when compared to control ($p \leq 0.05$), but no significant difference in the remaining experimental groups ($p > 0.05$).

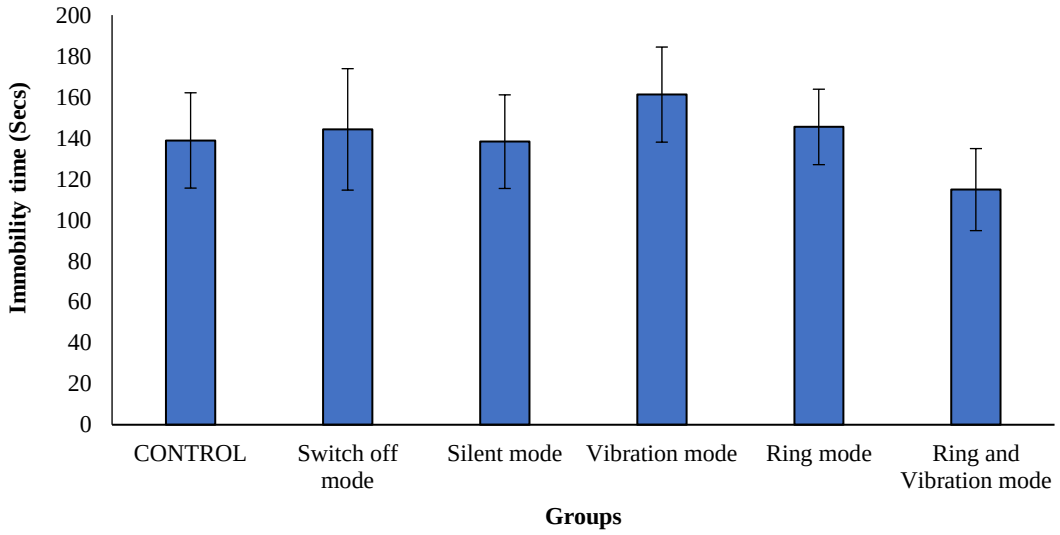

Figure 5.1: Effect of Exposure to Mobile Phone Radiation on Immobility Time in Tail Suspension Test in Mice

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test.

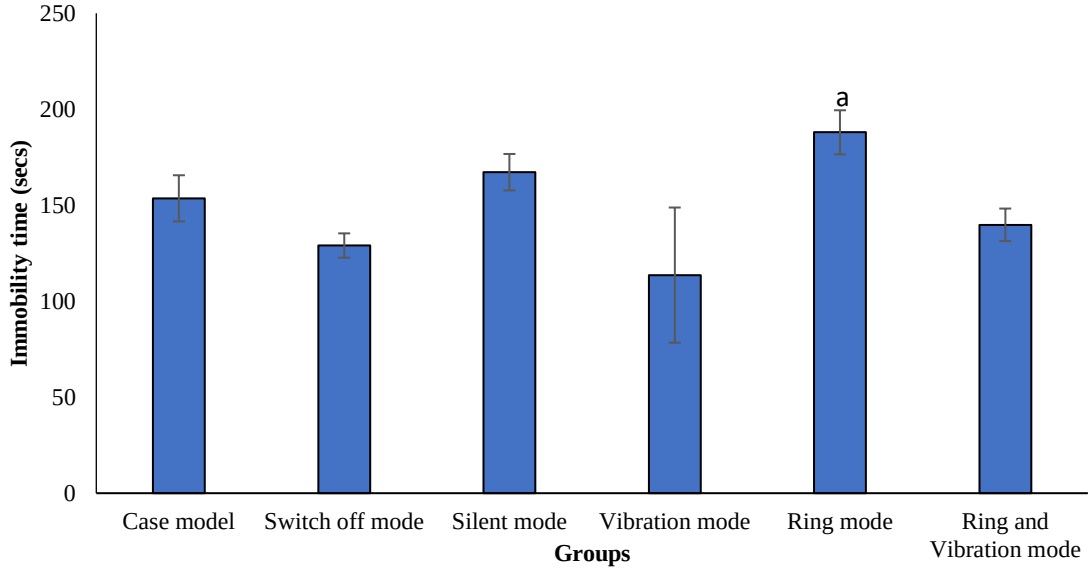

Figure 5.2: Effect of Exposure to Mobile Phone Radiation on Immobility Time in Forced Swim Test in Mice

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control.

6.0 Pain perception

The result on thermal pain threshold in mice using Eddy's hotplate model as shown in **figure 6.1**, there was a significant, shows no statistically significant difference in all the groups ($p > 0.05$). However, the result of mechanical pain threshold as presented in **figure 6.2**, shows a significant decrease in mechanical pain threshold in the ring and vibration mode when compared to both control and switched off mode ($p \leq 0.05$).

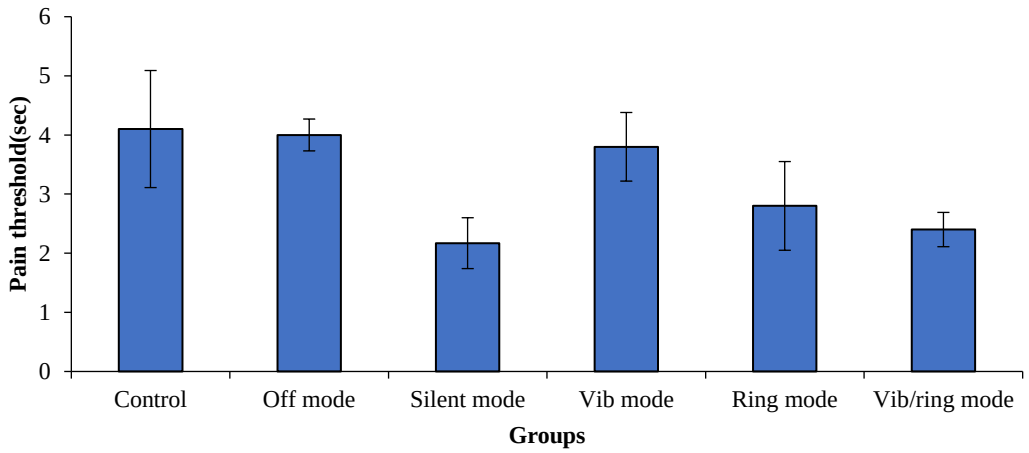

Figure 6.1: Effect of Mobile Phone Radiation on Thermal Pain Threshold Using Hotplate Model in Mice

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test.

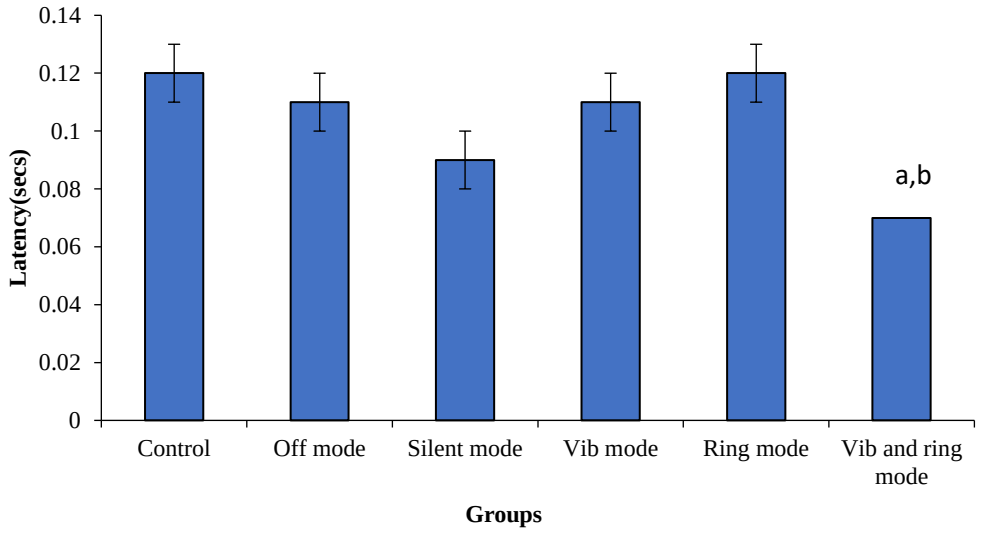

Figure 6.2: Effect of Mobile Phone Radiation on Mechanical Pain Threshold Using Paw Pressure Analgesiometer Model in Mice

Results are presented as Mean ± Standard error of mean of ten (10) mice. Data was analyzed using one-way ANOVA followed by Tukey's *post hoc* test. a = significant difference ($p \leq 0.05$) when compared to control, b = significant difference ($p \leq 0.05$) when compared to off mode.

A) Stage 2: Neurobehavioral and Cognitive Studies. The Neurobehavioral tests (biochemical, oxidative stress as well as the neurotransmitter studies) were successfully conducted. The topics (parts of the main project) and the students under my supervision that were assigned the sub topics undertook the studies were:

1) Effects of Mobile Phone Radiation On Motor Coordination in Female Mice **(Anthonia OCHEKWU, U15HP1090)**

Experimental animals

A total of sixty (30) mice of both sex with weight ranging from 18-20 g were used for this study, the animals were gotten from the Department of Pharmacology Faculty of Pharmaceutical Sciences Ahmadu Bello University Zaria, the animals were housed in polypropylene cages and allowed to acclimatize to the environment of the behavioral laboratory for the period of one week before commencement of the experiment with free access to feed and water. All experimental protocols were in accordance with the Research policies of Ahmadu Bello University Zaria, ethic and regulations governing the care and use of

experimental animal globally. The mice were randomly divided into six groups of 5 mice each (n=5) as follows:

Group i: mice were exposed to mobile phone radiation (control group).
Group ii: mice exposed to mobile phone radiation in switched off mode (model control). Group iii: mice exposed to mobile phone radiation in silent mode.
Group iv: mice exposed to mobile phone radiation in vibration mode.
Group v: mice exposed to radiation in ringtone mode.
Group vi: mice exposed to radiation in both ringtone and vibration mode.
The animals in group iii-vi were exposed to one-hour call (between 9:00am-12:00pm) per day for five (5) weeks.

Standardized tests were done for motor coordination using two experimental behavior paradigms: ***beam walk assay and hang test models.***

Beam walk assay

Mice were trained to walk from a start platform along a ruler (80 cm long, 3 cm wide) elevated 30 cm above the bench by metal supports to a goal box (enclosed hamster house). Three trials were performed for each mouse, and were designed such that the mice tested would be aware that there was a goal box that could be reached. A ruler was used because the mice found this easy to cross and, at the same time, it induced minimum anxiety. The mice were placed on the beam at one end and allowed to walk to the goal box. Mice that fell were returned to the position they fell from, with a maximum time of 60 s allowed on the beam. The measurements taken were latency and footslips (Stanley *et al*., 2005).

Hang Test Model

The test began when the animal was placed on the top of the cage which is then inverted and suspended above the home cage, the latency to when the animal falls is recorded. The test is performed two times and the average is taken.

Results Summary

Based on the Results obtained from this study, mobile phone radiation exposure in female mice for one hour per day for the duration of five weeks caused impairment of motor coordination in the ringtone mode.

Recommendations

Based on result of this study the following is recommended:

i. Nigerian telecommunications commission should endeavor to advise citizens on the type of phones to purchase to minimize the exposure to mobile phone radiation.

ii. Nigerian telecommunications should also monitor the type of phones that enter Nigeria ensuring that mobile phones do not exceed the stipulated SAR value.

2) Effect of Mobile Phone Radiation on Learning and Memory **(Husseina Ibrahim, U15HP1094).**

Experimental animals

A total of Thirty (30) mice weighting from 18g-30g were used for the whole study. These mice were divided into 6 groups. They were purchased from the department of Pharmaceutical science, Faculty of pharmaceutical science, Ahmadu Bello University, Zaria to the Department of Human Physiology, Faculty of Basic Medical Sciences, College of Medical Sciences, Ahmadu Bello University, Zaria.

The animals were housed in a Polypropylene cage and are allowed to acclimatize to the environment of the behavioral laboratory within the period of 5 days before commencement of the experiment with free access to feed and water. The mobile phones were introduced to the animal cages during the acclimatization period to exclude the effect of handling, anxiety and novelty on behavior. All experimental protocols were in accordance with the Research policies of Ahmadu Bello University Zaria), ethic and regulations governing the care and use of experimental animal globally. The experiment was conducted in between early hours of 9am to 12am daily for five weeks.

The animals were randomly divided into six groups of 5 animals each (n=5) as follows:

- **i.** Group I: Exposed to empty case of mobile phone (Control group)
- **ii.** Group II: Exposed to mobile phone in switched off mode,
- **iii.** Group III: Exposed to mobile phone in silent mode,
- **iv.** Group IV: Exposed to mobile phone in ringtone mode,

v. Group V: Exposed to mobile phone in vibration mode,

vi. Group VI: Exposed to mobile phone on ring and vibration mode

The animals in groups III to VI were exposed to 60 minutes call (120 missed calls for 30 seconds each) per day, ***Itel model it2106 with SAR 2W/ KG*** were introduced into the cages phones from group III to VI were simultaneously called for an hour with assistance from my team for a period of 5 weeks. At the end of the exposure, the mice were subjected to neurobehavioral models of learning and memory using Morris water maze and Novel object recognition test.

The animals in group II to VI were exposed to 60 minutes call (for 120 seconds each) per day for 5 weeks. At the end of the exposure weeks, the mice were subjected to neurobehavioral models of spatial memory testing using ***Morris water maze*** and ***Novel object recognition test***

Morris water maze (MWM) for the assessment of long term memory

Testing in the Morris water maze lasted for three days, 2 days' acquisition or learning phase and one (1) day probe or memory retrieval phase. During the acquisition phase, mouse underwent four training trial per day with inter-trial interval of six minutes, during which latency to find escape platform was recorded in seconds and averaged for the day. During the probe trial, frequency of platform location crossing was counted for sixty seconds. A video camera was fixed to the ceiling over the center of the maze (located in a large and quiet test room) to record the trials.

Novel object recognition test for the assessment of long term memory

Test commenced 24 h after the last habituation trial. For the exposure phase, two identical copies of the sample object (A1 and A2) were placed in the arena 10 cm away from the two adjacent corners of the north wall of the box and mice were allowed to explore the objects for 5 min. Mice were returned to the test arena for 5 min for the test phase. During the test phase the arena contained a third, identical copy of the object that was used in the exposure phase (A3), and one novel object (B1). Each object is placed in a location previously occupied by the sample objects in the exposure phase. The orientation of the familiar object (A3) in the test phase was the same as in the exposure phase.

On each trial mice were placed in the arena facing the south wall and thus, facing away from the objects in the exposure and test phase. The arena and objects were wiped down with 70% ethanol between trials to minimize olfactory cues. The mice were tested using the familiar object and the novel object. Object exploration was measured, as time spent with the nose <1 cm away from an object. Video footage of the exposure and test phase was scored. No criteria are placed on exposure phase object exploration. However, if mice showed <1 sec total object exploration during the test phase, then they are removed from the analyses of the novel object preference in the test trial. All test trials are scored for the whole 5 minutes' duration. Percentage preference was measured by [DI = $(T_N-T_F)/ (T_{N+}T_F)$ 100]. DI refers to the discrimination index, that allows discrimination between the novel and the familiar object This, T_N is time devoted to new object while T_N is time devoted to familiar object. Result may vary between +1 and -1 where positive score indicate more time spent with the novel object and negative score indicate more time spent with the familiar object while a zero score indicate null preference (Antunes and Biala 2011).

Results summary

From the experiment it can be concluded that mobile phone radiation impairs learning and memory this is as a result of increase latency seen in NORT (mice spent more time on familiar object than the novel object) and MWM (this increase was in silent ring, vibration, ring and vibration with the control significantly decrease).

Recommendations

- **i.** Mobile phones should be kept on silent mode this is because phones on ring tone, ring and vibration mode and vibration mode is seen to emit more radiation.
- **ii.** Minimize hours spent on phones (mostly on social media and the internet) as long hours spent could expose one to cell phone radiation.

3) Effect of Mobile Phone Radiation on Lipid Peroxidation in the Brain of Albino Mice **(Hauwa Salmanu MUHD, U15HP1107).**

Experimental animals

Thirty (30) males and thirty (30) females Albino mice in total were used for the whole studies which were purchased from the Department of Pharmacology, Faculty of pharmaceutical sciences. They were housed

in polypropylene cages and allowed to acclimatize to the environment of the behavioral laboratory for the period of one week (1) before commencement of the experiment with free access to feed and water. The mobile phones were also introduced to the animal cages during the acclimatization period to exclude the effect of handling anxiety and novelty on behavior. All experimental protocols were in accordance with the Research policies of Ahmadu Bello University Zaria), ethic and regulations governing the care and use of experimental animal globally. The experiments will be conducted in a quiet laboratory between hours of 900 h to 1600 h. The animals were randomly divided into six (6) groups of ten (5) mice each (n=5) as follows:

Group I: Control group exposed to phone case
Group II: Model control group exposed to phone in switch off mode
Group III: Exposed to mobile phone in silent mode,
Group IV: Exposed to mobile phone in vibration mode,
Group V: Exposed to mobile phone in ringtone mode,
Group VI: Exposed to vibration and ring tone.

The animals in groups III to VI were exposed to 1 hour call (each) per day for five (5) weeks.

Preparation of brain homogenate

The cranium was dissected and the brain was divided along the median plane into right and left hemispheres. The left hemisphere in males and right hemisphere in females was removed, homogenized using the vortex mixer (1 g of tissue/9ml) in 100mM phosphate buffer (pH 7.4). It was centrifuged at 9000×*g* for 30min and the supernatant was used for estimation of malondialdehyde.

Estimation of malondialdehyde concencentration

The lipid peroxidation, total MDA levels were measured using a spectrophotometric MDA-586 kit. Malondialdehyde was measured from the brain homogenate and plasma quantitatively. The level of thiobarbituric acid reactive substance was also determined based on the principle of its reaction with MDA to form MDA-TBA2 adduct that absorbs strongly at 532nm (Janero, 1990).

Results Summary

From the result obtained in this project, it shows that radiation stress caused an increase in the MDA content in male albino mice leading to enhanced lipid peroxidation, and has increase but not significant effect on female albino mice.

Recommendations

Having analyzed the effect of mobile phone radiation on MDA Level, from the result I obtained in this project, the following are my recommendations:

i. Mobile phones should be kept in silent mode because from the result obtained it has lesser effect than vibration mode, ring mode and ring/vibration mode.
ii. To prevent the development of lifestyle diseases, advice by medical professionals on how to lead a healthy life should be taken into serious consideration and be given to individuals based on the levels of oxidant and antioxidant activity assessed by pertinent biomarkers.

4) Effects of Mobile Phone Radiation on Pain Perception in Female Mice **(Firdausi ZAKARI, U15HP1114).**

Experimental animals

A total of thirty (30) mice weighing between 18-23g were obtained from the faculty of pharmaceutical science animal house Ahmadu Bello University Zaria. They were housed in polypropylene cages and were maintained and allowed free access to food and water. The animals were acclimatized for one week before commencement of the experiment. All animal experiments were carried out in accordance with Ahmadu Bello university ethical committee acts. Th**e** animals were divided into 6 groups of 5 mice each (n=5) as follows:

Group I: mice were exposed to empty phone cases (control),
Group II: mice were exposed to mobile phone in switched off mode (model control),
Group III: mice were exposed to mobile phone in silent mode,
Group IV: mice were exposed to mobile phone in vibration mode,
Group V: mice were exposed to mobile phone in ringtone mode,
Group VI: mice were exposed to mobile phone in vibration and ringtone mode.

The animals in groups III to VI were exposed to 1 hour call (60 missed calls for 1 minute each) per day for 5 weeks. Assessment of pain perception was conduction using hot plate and

Assessment of pain perception using hot plate

The hot plate test is a test of pain response in animals, similar to the tail flick test. Both hot plate and tail-flick methods are used generally for centrally acting analgesic (Carlsoon, 1897) while peripherally acting drugs are ineffective in these tests but sensitive to acetic acid-induced writhing test (Matera, 2014). The hot plate test is used in basic pain research and in testing the effectiveness of analgesics by observing the reaction to pain caused by heat. It was proposed by Eddy and Leimbach 1953 (Eddy, 2018). We used a behavioral model of nociception where behaviors such as jumping and hind paw-licking are elicited following a noxious thermal stimulus. Licking is a rapid response to painful thermal stimuli that is a direct indicator of nociceptive threshold. Jumping represents a more elaborated response, with a latency, and encompasses an emotional component of escaping.

(i) A transparent glass cylinder was used to keep the animal on the heated surface of the plate.

(ii) The temperature of the hot plate was set using a thermoregulated water-circulated pump.

(iii) The time of latency is defined as the time period between the zero point, when the animal is placed on the hot plate surface, and the time when the animal licks its paw or jumps off to avoid thermal pain.

Assessment of pain perception using Analgesiometer model

The paw pressure analgesiometer was used for this experiment, it is a classical device used to perform paw pressure experiment which is used to measure pain threshold. The force was applied on the mice paw, which was placed on a small plinth under a cone shaped pusher with a rounded tip, which does not hurt the mice. I then depressed a pedal- switch to start the mechanism which exerted the force; when the mice struggled it was released the pedal and took the readings off the scale, the force at which the mice felt pain (Barton, 2007).

Results summary

From this study it can be concluded that exposure to mobile phone radiation in female mice has an effect on the pain threshold and pain perception.

Recommendations

(i) The prevalence of cell phone radiation exposure can be combated through many different means.

Exposure to this radiation, whether the risks are more or less real than believed, can be reduced. This study showed that the exposure to mobile phone radiation has an effect on pain threshold increasing the pain perception.

(ii) Further studies should be done with different pain models to be able to access the effect of mobile

radiation on the pain perception as then hot plate did not show any significance.

(iii) Mobile phones should be kept on silent as it emits less radiation.

5) Effect of Exposure to Mobile Phone Radiation on Depressive-Like Behaviour in Albino Mice **(Khalid Muhammad KHAMIS, U16HP2014).**

Experimental animals

Sixty (60) Albino Mice (30 males and 30 females) weighing from 14-24g were used for this research. The animals were obtained from the Faculty of Pharmaceutical sciences, Ahmadu Bello University, Zaria. The animals were housed in the animal house of the Department of Human Physiology, Ahmadu Bello University, Zaria, Nigeria. They were kept in cages under normal environmental temperature and were allowed to acclimatize for one week before the onset of the experiment. The mice were fed with vital feeds growers mesh and water *ad libitum.* The mobile phones Itel with model: it2160 and specific absorption rate (SAR) of 2w/kg was also introduced to the animal cages after the acclimatization period to exclude the effect of handling, anxiety and novelty on behavior. All experimental protocols were in accordance with the Research policies of Ahmadu Bello University Zaria, ethic and regulations governing the care and use of experimental animal globally. The animals were divided into six (6) groups of ten (10) mice each (5 males and 5 females) as follows:

Group I: Mice exposed to mobile phone case (control)

Group II: Mice exposed to mobile phone in switched off mode (Model control)

Group III : Mice exposed to mobile phone in silent mode

Group IV: Mice exposed to mobile phone in vibration mode.

Group V: Mice were exposed to mobile phone in ringtone mode.

Group VI : Mice exposed to mobile ringtone and vibration

The animals in groups III- VI were exposed to 120 missed calls for 1 hour per day for five (5) weeks.

Forced swim test (FST) in male albino mice

The FST was performed with a glass cylinder (20 cm diameters 30 cm height) filled with warmwater (23–25 C). The water level was 15 cm from the bottom so that the mice were not able to touch the bottom of the tank, either with their feet or tails, during the swimming test. A total of 6 min of testing was carried out and only the last 4 min of the test were analyzed. The mobility time was measured in seconds only when the mice do any movements other than those necessary to balance the body and keep the head above the water. All data were analyzed by two observers who were blind to the group assignment of animals (Zhang *etal*., 2017).

Tail suspension test (TST) in female albino mice

The TST is a test conducted to test the antidepressant potentials of drugs, or to test the result of experimental manipulations proposed to affect depression related behaviours. The apparatus was made up of ply wood of suspension box with total dimension (55cm height x 60cm width x 11.5cm depth). The suspension box is divided in to six compartments with dimension (55cm height x 15cm width x 11.5cm depth). Tape of 17cm long was used and the tail of the mice was place on 2cm mark with 2-3millimeter of tail remaining outside the tape. With the climb stopper on the tail, the Mice were suspended by placing the free end of the tape on the suspension bar. The duration of immobility was recorded during a period of 6 minutes. The suspension compartment was wiped between observations with spirit and allowed to dry to remove any olfactory cue (Silva *et al*., 2013). Immobility = Total time - Mobility

Results summary

At the end of this study, it was determined that forced swim test (FST) and tail suspension test (TST) did not have effect on behavioural changes associated with depression in the mice.

Recommendation

i. Further studies with forced swim test and tail suspension test should consider increasing the time and duration of the exposure.

ii. Other models of inducing depression should be explored to assess the depressive-like behaviour in mice.
iii. More research should be conducted using mobile phones with higher specific absorption rate (SAR).
iv. Biochemical analysis should be carried out to assess the level of biomarkers for depression after exposure to mobile radiation.

6) Effects of Mobile Phone Radiation on Learning and Memory **(Sa'adatu Adamu GOKARU, U15HP1055).**

A total of thirty (30) albino male mice weighing between 18-25g were divided into six groups of 5 mice each. They were purchased from the department of Pharmaceutical science, Faculty of pharmaceutical science, Ahmadu Bello University, Zaria to the Department of Human Physiology, Faculty of Basic Medical Sciences, College of Medical Sciences, Ahmadu Bello University, Zaria.

The animals were housed in a Polypropylene cage and are allowed to acclimatize to the environment of the behavioral laboratory within the period of 5 days before commencement of the experiment with free access to feed and water. The mobile phones were introduced to the animal cages during the acclimatization period to exclude the effect of handling, anxiety and novelty on behavior. All experimental protocols were in accordance with the Research policies of Ahmadu Bello University Zaria), ethic and regulations governing the care and use of experimental animal globally. The experiment was conducted between the early hours of 9 am to 12 am daily for five weeks. The thirty mice were randomly divided to groups, six groups of 5 mice per cage (n=5):

Group I: were exposed to empty phone case (control),
Group II: were exposed to mobile phone in switched off mode (model control),
Group III: were exposed to mobile phone in silent mode,
Group IV: were exposed to mobile phone in vibration mode,
Group V: were exposed to mobile phone in ringtone mode,
Group VI: were exposed to mobile phone in vibration and ringtone mode.
The animals in groups III to VI were exposed to 60 minutes call (120 missed calls for 30 seconds each) per day for 5 weeks. At the end of the exposure, the mice were subjected to neurobehavioral models of learning and memory using Barnes maze and Elevated plus maze.

Barnes maze

Barnes maze consist of a circular table with holes around the circumference, placed in a room with visual cues in the periphery. Most of these holes lead to an open drop to the floor, but a single hole leads to a drop box, a dark box where the animal could hide. A rodent is naturally motivated to avoid open spaces and bright lights and therefore attempts to find the drop box. In initial trials, mice were led to the drop box while in subsequent trial animal was placed in the center of the table and left to find the drop box on its own. After few trials, rodent typically remember which hole contains the drop box and quickly proceed in a direct path towards the pole. The time taken is recorded and the number of incorrect holes explored (Barnes, 1979).

Elevated plus maze

Behavioral responses in rodents were measured by elevated plus maze. The elevated plus-maze measures short term memory which consisted of two open arms (25 × 5 cm) and two enclosed arms of the same size with 15-cm high walls. The arms and central square were made of black plastic plates and elevated 55 cm above the floor. Arms of the same type are located opposite from each other (Lister, 1987). On the training day (first day), each animal was placed at the end of one open arm, facing away from the central platform. The latency of the mouse to move from the open to the enclosed arms was recorded within 90s. Following entry into the arm, the animals were allowed to explore the apparatus for 20s, after each trial the maze is wiped with cloth dipped in methylated spirit and allowed to dry. Twenty-four hours later, the second trial (retention test) was performed and the latency was within 90 seconds.

Results Summary

From the result obtained here, it says that there is decrease in long term memory after mobile phone exposure for five weeks. It was also observed that there is higher decrease in memory when mice were exposed to mobile phones in vibration and ring mode, ring mode and also the silent mode.

Recommendations

Based on the results obtained, the following suggestions and recommendations are made, which can be carried out to reduce or minimize the effect of mobile phone radiation

(i) Mobile phones should not be constantly put in vibration and ring mode.

(ii) Mobile phones should be put in switched off mode when not in use.

(iii) The time spent by a person using mobile phons should be reduced.
(iv) Further studies should be carried out to investigate the adverse effects of increased duration of mobile phone usage and also to check on the levels of neurotransmitters involved in memory.

7) Effects of Mobile Phone Radiation on Anxiety- Like Behavior in Females Mice **(Mansur Abduljalil SALISU, U14HP1117).**

Experimental animals

A total of thirty (30) albino mice (18g to 20g) were used to conduct the experiment. They were purchased from the Animal house, Department of pharmacology, Faculty of pharmaceutical sciences, Ahmadu Bello University, Zaria, Kaduna State, Nigeria. They were kept in animals' house Department of Human physiology, Faculty of Basic Medical Sciences, Ahmadu Bello University, Zaria. They were housed in a white plastic cages containing sawdust bedding. They were fed with pallets made from growers mash, with maize offal as binder and water. They were acclimatized for one week before commencement of the experiment. The animals were grouped into six (6), each group consisting of five (5) mice as follows:

Group 1: They were not exposed to mobile phone's radiation (phone's case)
Group 2: were exposed to mobile phone in switched off mode (serve as model control)
Group 3: were exposed to mobile phone in silent mode
Group 4: were exposed to mobile phone in vibration mode
Group 5: were exposed to mobile phone in ring tone mode
Group 6: were exposed to mobile phone in vibration and ring tone mode

The animals in groups III to VI were exposed to 10 minutes call (30 missed calls for 20 seconds each) per day for five (5) weeks. At the end of the exposure weeks, the mice were subjected to neurobehavioral models of anxiety-like behavior.

Open field test (OFT)

The open field apparatus was constructed by wood and measured (72 x 72 x 36cm) and the floor is divided into 16 equal squares by green lines. One of the walls of the apparatus is clear transparent glass, so that the mice can be visible in the apparatus. Before the commencement of the test, the mouse was placed at

the center of the floor space and allowed to acclimatize with the surrounding area for 2 minutes (Yusha'u *et al*., 2017).

The mouse was placed in one corner of the apparatus and the number of line crossing (as an index of locomotor activity) which indicated by the total number squares crossed (Yusha'u*et al*., 2017), rearing responses (Mangaiarkkarasi*et al*., 2012), center crossing, grooming, number of urine and feces (as an index for anxiety) were counted over a period of five minutes. The apparatus was cleaned after every use (Mangaiarkkarasi*et al*., 2012).

Hole Board Test

The hole board test is rodent neurobehavioral model test for measuring head dipping activity. Changes in head dipping activity have been considered to be related to anxiety. The hole board apparatus consists of an enclosed space, the floor of which has sixteen holes in a grid pattern. The rodent, when placed in the apparatus, is free to dip its head through the holes in the floor; the frequency and duration of this behavior, known as (head dipping) is thought to measure levels of neophilia. The number of head dipping was recorded within five (5) minutes. (Takeda *et al.*, 1998).

Results summary

The study showed that the mobile phone's radiation has effect an on Anxiety like behavior in mice exposed to mobile phone's radiation using hole board test. However, it showed that the mobile phone's radiation did not have effect on Anxiety like behavior in mice exposed to mobile phone's radiation using open field test.

Recommendations

Based on the results, the following recommendations are made:

i. The neurotransmitters such as serotonin should be assessed to determine the effect of mobile phone's radiation in mice.
ii. The biochemical analysis should be conducted to measure the biomarkers of anxiety on the animals.

8) Evaluation of the Effects of Mobile Phone Radiation on Brain Electrolytes Concentration in Male Albino Mice **(Muhammad Abdulsalam OMISANYA (U15HP1006).**

Experimental animals

A total of thirty (30) male albino mice with the weight ranging from 18g to 25g were used for the whole study. The mice were obtained from the Faculty of Pharmaceutical Science Animal House, Ahmadu Bello University, Zaria. The mice were housed in polypropylene cages in the animal house of the Department Human Physiology, Faculty of Basic Medical Sciences, College of Health Sciences, Ahmadu Bello University, Zaria with free access to food and water *ad libitum*. The mice were allowed to acclimatize to the environment of the behavioral laboratory for the period of one week before commencement of the experiment. The mobile phones were also introduced to the animal cages during the acclimatization period to exclude the effect of handling, anxiety and novelty on behavior. All experimental protocols were in accordance with the Research policies of Ahmadu Bello University Zaria, ethic and regulations governing the care and use of experimental animal globally. The experiments were conducted in a quiet laboratory between hours of 9:00 h to 12:00 h daily. The mice were divided into six (6) groups comprising of five (5) mice (n=5) each as follows:

i. Group I was exposed to mobile phone case
ii. Group II was exposed to mobile phone in switched off mode (model control)
iii. Group III was exposed to mobile phone in silent mode.
iv. Group IV was exposed to mobile phone in vibration mode.
v. Group V was exposed to mobile phone in ringtone mode.
vi. Group VI was exposed to mobile phone in vibration/ringtone mode.

The animals in groups III to VI were exposed to 1 hour (120 missed calls) per day for 5 weeks.

Animal sacrifice and preparation of brain homogenate

After 5 weeks of exposure to mobile phone radiation, the mice were sacrificed by given mild doses of chloroform. The brain was resected, weighted and homogenized with 9 ml of phosphate buffer, the homogenate was centrifuged at 9000×*g* for 30 min and the supernatant was used for analysis of brain electrolytes (Na^+, K^+ and Ca^{2+}).

Determination of brain sodium concentration

Sodium is estimated by colorimetric method, sodium and proteins are precipitated together by Magnesium uranyl acetate as Uranyl Magnesium Sodium Acetate Salt. Excess of uranyl salt react with potassium ferrocyanide to produce a brownish color. The intensity of the color is inversely proportional to the concentration of sodium in the specimen and is measured photometrically at 530nm.The supernatant was transferred immediately to the colorimeter after centrifugation where the absorbance was measured.

Determination of brain potassium concentration

Potassium is estimated by turbidometric method. The extent of turbidity is proportional to the concentration of potassium and is measured photometrically at 578 *nm* (570-620nm). The absorbance of standard sample and test sample was measured against distilled water at 578 *nm* within 10 minutes.

Determination of brain calcium concentration

Calcium OCPC (O-cresolphthalein) procedure is based on the reaction of calcium ions (Ca^{2+}) with O-cresolphthalein complex in an alkaline solution to form an intense violet colored complex which shows maximum absorbance at 578nm. The 8-hydroxy quinoloine prevents Mg^{2++} interference up to 4 mmol/L. The supernatant was mixed with the reagents and incubate for 5 min. at room temperature, the absorbance of standard and sample was read against that of reagent blank.

Results summary

The study reveals that exposure to mobile phone radiation for 5 weeks in albino male mice showed a significant increase in concentration of Na^{+} and Ca^{2+} in the brain which is due to the effect of EMR on the permeability of BBB leading to influx of Na^{+} and Ca^{2+}, in addition there was no statistically significant difference in the effect of mobile phone radiation on the concentration of K^{+} in the brain.

Recommendations

i. The duration of exposure should be extended more than 5 weeks and the number of missed calls should be increased beyond the initial 120 missed calls per day.
ii. Further studies should be carried out to evaluate the effect of mobile phone radiation on the concentration of other brain electrolytes.
iii. Mobile phones should be put on silent or switch off mode as it has lesser effects on brain electrolyte concentration

9) Effects of Mobile Phone Radiation on Antioxidants in Mice Brain **(Muhammad TIJJANI, U15HP1052).**

Experimental animals

Thirty mice were obtained from the Faculty of Pharmaceutical Sciences' animal house Ahmadu Bello University, Zaria. They were housed in polypropylene cages and were maintained and allowed free access to food and water. The animals were acclimatized for one week before commencement of the experiment. All animal experiments were carried out in accordance with Ahmadu Bello University ethical committee acts. The animals were randomly divided into six groups of five (n=5) mice per group:

Group I: were not exposed to mobile phone case placed in the cage.
Group II: were exposed to mobile phone in switched off mode (model control group),
Group III: were exposed to mobile phone in silent mode,
Group IV: were exposed to mobile phone in vibration mode,
Group V: were exposed to mobile phone in ringtone mode, and
Group VI: were exposed to mobile phone in vibration and ringtone mode. The animals in groups II to V were exposed to 1hour call (120 missed calls) per day for 5+ weeks.

Preparation of brain homogenate

At the end of the exposure weeks, the animals were sacrificed using chloroform and the brain was carefully extracted and incubated on an ice for cleaning and then homogenized in 9ml phosphate buffered saline (PBS) (pH 7.4) to every 1g of tissue followed by centrifuging for biochemical study of SOD activity and GSH concentration of the brain. The homogenates were centrifuged for 10 min at 3000rpm upper clear supernatants were removed, and used for the analysis.

Determination of superoxide dismutase (SOD) activity

Superoxide dismutase (SOD) was determine by the method describe by Fridovich (1989). The ability of superoxide dismutase (SOD) to inhibit autooxidation of adrenaline at pH 10.2 formed the basis of this assay. 0.05M carbonate buffer: 114.3g of Na_2CO_3 and 4.2g of $NaHCO_3$ was dissolved in distilled water and was made up to 1000ml in a volumetric flask. The buffer was adjusted to pH 10.2.0.3mM Adrenaline: 0.01g of adrenaline was dissolved in 17ml of distilled water, the solution was prepared fresh.

Tissue homogenate of 0.1 ml was diluted in 0.9 ml of distilled water to make 1:10 dilution of microsome. An aliquant mixture of 0.2 ml of the diluted micro some was added to 2.5ml of 0.05M carbonate buffer. The reaction started with the addition of 0.3 ml of 0.3 mM Adrenaline. The reference mixture contained 2.5 ml of 0.05M carbonate buffer, 0.3 ml of 0.3 mM Adrenaline and 0.2ml of distilled water. The Absorbance was measured over 30 seconds up to 150 seconds at 480 *nm*.

Determination of reduced glutathione concentration

Reduced glutathione (GSH) was determined by the method of Ellman (1959). About 1 ml of supernatant (0.5 ml serum precipitated by 2 ml of 5% TCA) was taken and 0.5 ml of Ellman's reagent (0.0198% DTNB in 1% sodium citrate) and 3 ml of phosphate buffer (pH 8.0) was added. Following colour development, absorbance was taken at a wave length of 412 *nm*.

Results summary

In conclusion, the result of the present study indicates that five weeks' exposure to electromagnetic radiation in combination with either vibration, ringtone or both have no effect on antioxidant in mice brain.

Recommendations

(i) Further studies should be performed with mobile phones with higher specific absorption rate (SAR).
(ii) Further studies should be performed with increase duration of exposure.

Stage 3a: Data analysis of the Research Results: The results of the researches conducted for the above students were analyzed, presented and defended at the Department of Human Physiology, Faculty of Basic Medical Sciences, Ahmadu Bello University, Zaria before an External examiner (Project external defense) as part of the requirements for the award of a B.Sc. Human Physiology and projects have passed with an **"A" Grade**. The projects have passed Departmental, Faculty and College Boards and awaiting Senate approval for graduation.

a) **Stage 3b: Manuscript(s) Development:** Manuscripts have been developed from the research work and now going through proofreading before submission for publication by (a) reputable journal(s).

STAGE 4 DELIVERABLE

It should be noted that our research is medical research to assess whether or not the mobile phones mostly used in Nigeria produced appreciable radiation that could be detrimental to humans (especially in the Brain) and possible chemical agent that could counteract it. This means that our research is not expected to produce any prototype product as misunderstood by your office as it is applicable to the other research projects that have won the NCC grants in ABU. You may recall that this explanation on the scope of our work according to our submitted proposal was contained in the first letter I wrote and sent to the Executive Vice Chairman's office not long after the award ceremony in order clear the misconception of the need for prototype for our project work.

Moreover, if you carefully examine our approved proposal submitted to you, there is no provision of the production of any prototype. What our project has since inception intended and presented to you has been to establish the baseline survey of the effect of the mobile phone radiation which our results have established and submitted in the series of the comprehensive reports sent to you. You may recall that We even sent you the complete written manuscript which is just waiting publication only that We are waiting for the disbursement of the final 20% for us to submit the manuscript and consequently send you the published article(s) upon publication.

Way forward for the final disengagement of this Research Grant Project are therefore:

a) It is expected that the NCC should consider our final comprehensive report submitted on ***30th November, 2020*** and consider completing the ***final 20% payment*** to enable my research team complete the necessary processes of publishing our manuscript(s) thereby ending the project.

b) It is the commitment of my Research team that as soon as the last payment is made, it will not exceed two Months for us to successfully finish the processes of submitting the final manuscripts and then await the publication of the manuscript(s) by Journal(s).

Finally, we are using this avenue to apply for the final disbursement of the last trench of 20%.

Yours faithfully,

Professor Rabiu AbduSSALAM Magaji