Effect of Selenium-yeast on Cognitive Performance on Pregnant Dams Exposed to Noise Stress

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Authors' contributions

This work was carried out in collaboration among all authors. Authors OMO, BA and EI designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors DAUH and AEI managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

A total of twelve pregnant Wistar rats were used, and randomly divided into three groups (n=4). Group A (negative control), not exposed to noise stress), group B (1mL/kg of distilled water + 4h /15 days noise stress), group C (0.04 mg/kg) of selenium-yeast + 4 h/15 days noise stress). On day 18 and 19 of gestation cognitive tests were conducted using Y-maze and Novel Object Recognition Test. A significant increase ($P < 0.05$) was observed in the percentage alternation and discrimination index in group A compared with group B. However, the percentage alternation and DI were significantly ($P < 0.05$) decreased in group C compared with group B. In conclusion, noise stress induces cognitive deficit, this deficit can be mitigated with the administration of selenium-yeast.

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1. INTRODUCTION

Noise can be defined as the concomitant of unavoidable and unpleasant sounds that emerges from the environment in today's world via household appliances, worship centers, night clubs and urban traffic [1]. When noise exceeds 90 dB it's said to be a stress; which can induce harmful effects on the cardiovascular and central nervous systems [2]. Some studies have shown the adverse effects of noise stress on the brain as it induces behavioral changes and declines cognitive performance; with decrease in incidental, intentional and recognition memory in children [3,4]. A study conducted among industrial workers and individuals residing around major transports routes linked the occurrence of depression and aggression to noise exposure [4].

Since noise stress overwhelm the physiological adaptive mechanism by inducing excess secretion of glucocorticoids hormone in females when compared with males [5], and this secretion level has been found to increase during pregnancy; this may lead to a condition known as prenatal stress [6]. Prenatal stress has adverse effects on the structural and biochemical domain of fetal brain; by inhibiting neuronal development and might have possibly been the contributing factor to cognitive impairment [7]. One of the hypotheses of the effect of prenatal stress on the nervous system is due to the cortisol hormone crossing the blood-brain barrier, thereby inducing oxidative stress [8]. Since oxidative stress is the imbalance in the oxidants and antioxidants of the body; hence antioxidant is vital in mitigating the adverse effects of stress. Antioxidants are substances that inhibit oxidation caused by free-radicals in target cells; example of such is selenium which is a component of selenoenzymes [9]. Selenoenzymes are the families of glutathione peroxidases (GPXs), thioredoxin reductases (TRs) and iodothyronine deiodinases (Ds), and can be enriched with yeast to enhance potency [10].

However, most studies conducted on the impact of noise stress focused on the pubs while neglecting the pregnant dams, and also no effective therapy has been established in mitigating the resultant cognitive impairments. This study investigate the effects of selenium-yeast on the cognitive performance of the pregnant dams exposed to noise stress using object recognition and Y-maze test for cognitive performance measure.

2. MATERIALS AND METHODS

Twelve healthy female Wistar rats weighing 150–170 g were kept in the Animal House of Department of Physiology, Baze University Abuja, FCT-Abuja, Nigeria under standard laboratory conditions. The animals were divided randomly into three groups and a male rat was introduced to each group for mating. Pregnancy was confirmed by the presence of vaginal plug which was tagged pregnancy day zero (PD0). The rats were grouped as follow: group A – Negative Control (NC) (not exposed to noise + 1 mL/kg of distilled water), group B – positive control (noise stress at 100 dB for 4 h/15 day + 1 mL/kg of distilled water), and group C (noise stress at 100 dB for 4 h/15 day + 0.04 mg/kg of selenium-yeast via intragastric route. Noise was produced by a 15 W loudspeakers driven by a white noise generator. The noise was perceived at 100 dB throughout the cage as monitored by a sound-level meter D2023 (S.NO-F02199: Cygnet Systems, Gurgaon, Haryana, India). The cognitive test was conducted on pregnancy day 18 and 19. Two types of cognitive tests were performed, namely, the novel object recognition test that evaluates working memory and Y-maze for spatial memory test.

2.1 Novel Object Recognition Test

The test was conducted according to the method of [11] with a slight modification; using an open field box made of 50 cm × 50 cm × 50 cm. The rats were trained by allowing they explore the open field arena for 10 min prior to the testing day in the presence of two identical sample objects. The objects discriminated were made of wood distinguished in color and shape. In between the tests, the objects were cleaned with 10% ethanol solution to prevent olfactory cues. In the retention session, the rats were placed back in the same field, where one of the familiar objects was replaced by a novel object, and the rats were allowed to explore for 5 min. Exploration in this case is define as the directing of rats nose toward the object at a distance of 2 cm or less. It excludes climbing and leaning on the objects.

The total exploration time of the familiar and novel objects were used to calculate

discrimination index. The discrimination index is an index of measures of discrimination between the familiar and the novel objects corrected for exploratory activity. It is calculated as: (time spent on novel object − time spent on familiar object)/ (time spent on novel object + time spent on familiar object). The discrimination index ranges from −1 to 1, with −1 indicating complete preference for the familiar object, 0 indicating no preference for either object, and 1 indicating complete preference for the novel object [12].

2.2 Y-Maze Test

Y Maze is a behavioral test for measuring the willingness of rodents to explore new environments. Rodents typically prefer to investigate a new arm of the maze rather than returning to the one they previously visited. Many parts of the brain namely, hippocampus, septum, basal forebrain, and prefrontal cortex are involved in this task [13].

The Y-shaped maze has three arms at a 120° angle from each other (50 x 50x 50 cm). In this study, the working memory was assessed based on the existing protocols from previous literature [13]. The rat was placed at the center of the maze, and allowed to freely explore the three arms for 8 mins. The number of times the rats enter into each arm was counted; this is when all the four limbs are inside the arm. The number of arm entries and the number of triads or alternation (a triad when it visited all 3 arms consecutively) was used to calculate the percentage of alternation; which is a measure of working memory, the number of maximum spontaneous alternations is then the total number of arms entered, and the percentage alternation is calculated as (actual alternations /maximum alternations) x 100. If a rat scored significantly above 50% alternations, these indicate a functional working memory. Note, after each trial, the Y maze was cleaned with 5% ethanol that prevented olfactory cues.

2.3 Data Analysis

GraphPad Prism 8.4 (San Diego, California, USA) was the statistical package used. The results were expressed in mean (± SEM). And values of ($P < 0.05$) were considered statistical significant. One-way ANOVA was used to identify the difference between mean, followed by Tukey's post-hoc test.

3. RESULTS

3.1 The Effects of Selenium-yeast on the Percentage Alternation in Pregnant Dams Exposed to Noise Stress Using Y maze for Spatial Memory Test

The Percentage alternation above 50% is an indicator of spatial memory retention and below 50% indicates memory deficit. Fig. 1 shows a significant increase ($P = .05$) in Group A (58.7±4.360), when compared with Group B (24.37±2.37). However, there was no significant difference in Group A when compared with Group C (56.3±3.48). Though a statistical ($P = .05$) increase was observed in Group C the selenium-yeast administered group when compared with Group B noise stresses without antioxidant administration.
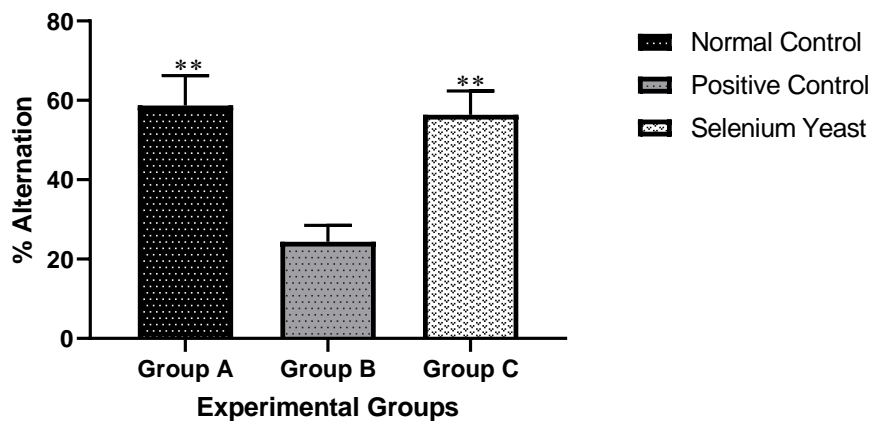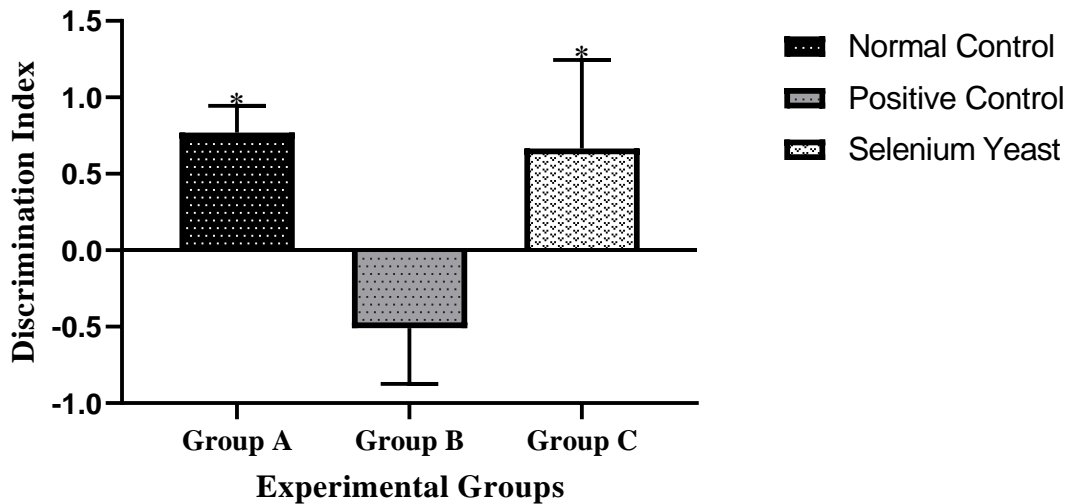

Fig. 1. The effects of selenium-yeast on the percentage alternation
n=4, □□ indicates the degree of significant (P = .05)

Fig. 2. The effects of selenium-yeast on discrimination index
n=4, □ indicate degree of significant difference (P <0 .05)

3.2 The Effects of Selenium-yeast on Discrimination Index in Pregnant Dams Exposed to Noise Stress Using Novel Object Recognition Test (NORT)

Discrimination index (DI), range from −1, 0 to 1, with −1 indicating complete preference for the familiar object, 0 indicating no preference for either object, and 1 indicating complete preference for the novel object recognition (NOR), since rodents naturally want to explore new things, hence scoring 1 indicates retentive memory. Fig. 2 shows a statistical increase (P = .05) in DI of Group A (0.77±0.11) when compared with Group B (-0.51±0.21). There is a significant increase (P = .05) in DI in Group C (0.67±0.33) when compared with Group B.

4. DISCUSSION

Noise stress is an inescapable phenomenon in modern era, since we are been faced with it from multiple sources from the environment, but the adverse effects of this stress differs among gender, and this tends to be exaggerated in pregnant state [5]. Some studies have linked noise stress with several neurological disorders in both human and rodents [3,4], despite these findings no effective measure have been established to halt this effect. Fig. 1 shows an increases in percentage alternation in the non-stress group when compared with the stress group on the NOR test, since decrease

alternation below 50 % indicates impaired spatial memory; hence this study agrees with previous studies that shows noise stress impairs cognition [14,15,16]. However, there was an increase in the percentage alternation in selenium-yeast administered group exposed to noise stress, this finding agrees with previous studies that have reported the role of selenium-yeast as a cognitive booster [17,18], this might be as a result of the antioxidants property of selenium-yeast in mitigating oxidative damages [18]. In Fig. 2, the discrimination index in the normal control group was significantly higher when compared with the stress control. The increase in discrimination index in group A indicates that rat not exposed to noise stress have a stable cognition, when compared with the stressed counterpart using the NORT; this study further buttress other report on noise stress inducing cognitive impairments [16,19]. However, the pre-administration of selenium-yeast prior to noise stress exposure was able to mitigate the negative effect that noise stress have on the cognition of pregnant dams which agrees with previous studies [17,20] on the effect of selenium-yeast on memory. This study investigates the effects of selenium-yeast on the cognitive performance of the pregnant dams exposed to noise stress.

5. CONCLUSION

In conclusion, the results from this study show that noise stress induces cognitive impairments in pregnant dams on Y maze and novel object

recognition test in Wistar rats. However, the impairment caused through noise stress can be mitigated with the pre-administration of selenium-yeast.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ETHICAL APPROVAL

The ethical clearance was obtained from the Baze University Abuja Animal Ethical Committee.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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