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The Effect of Zinc Supplementation of Lactating Rats on Short-Term and Long-Term Memory of Their Male Offspring

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ABSTRACT

Background: In this study the effect of zinc chloride ($ZnCl_2$) administration on the short-term and long-term memory of rats were assessed.
Methods: We enrolled six groups of adult female and control group of eight Wistar rats in each group. One group was control group with free access to food and water, and five groups drunk zinc chloride in different doses (20, 30, 50, 70 and 100 mg/kg/day) in drinking water for two weeks during lactation .One month after birth, a shuttle box used to short- term and long-term memory and the latency in entering the dark chamber as well.
Results: This experiment showed that maternal 70 mg/kg dietary zinc during lactation influenced the working memory of rats' offspring in all groups. Rats received 100 mg/kg/day zinc during lactation so they had significant impairment in working memory (short-term) of their offspring ($P<0.05$). There was no significant difference in reference (long-term) memory of all groups.
Conclusion: Drug consumption below70 mg/kg/day zinc chloride during lactation had no effect. While enhanced 100 mg/ kg/ day zinc in lactating rats could cause short-term memory impairment.

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Introduction

Zinc plays a functional role to regulate the release of neurotransmitters such a γ-amino butyric acid, acetylcholine and glutamate[1]. Zn deficiency in lactating mothers is characterized by neuro-anatomical malformations and functional abnormalities in suckling offspring[2]. Hippocampus as central center of memory is much more sensitive to Zn deficiency than other parts of the brain[3, 4]. Zn deficiency during gestation or lactation can impair learning and then memory later in adult hood[5]. Those rats given short-term high dose of zinc chloride 50 or 100 mg/kg by gavagefeeding had in spatial learning.

Adverse effects on humans have been previously reported at doses between 30-40 mg of zinc supplements daily[6]. Because blood–brain barrier acts to regulate the inflow of metals, it

seems that the short-term dietary administration does not change zinc levels [7-9]. Thus, Zn deficiency during development sounds to be quite inadequate[10]. Zinc is essential for the activity of over 300 enzymes involved in processes such as mitosis, gene expression and activation[11, 12]. Besides, physiological role of zinc during period of rapid growth and development has been emphasized[13]. In this study we aimed to study animal model to ascertain the effects of different doses of zinc supplementation during lactation on short and long memory of their offspring.

Material and Methods

Animals

Six groups of adult Wistar rats (200±30 g) were taken for this experiment. They were maintained in a 12 h light/dark-cycle and temperature-controlled (22-25 °C) animal room[2]. Lactating rats were separated from male rats and were divided into six groups. One group was control group with free access to food and water, and five groups drunk zinc chloride in different doses (20, 30, 50, 70 and 100 mg/kg/day) in drinking water for two weeks during lactation. All litters were weaned 25 days and given tap water until they were 30 days old.

Apparatus

The apparatus used for passive avoidance response training of their offspring was shuttle box that it consisted of two adjacent illuminated and light compartments separated by a guillotine door in the middle part of this apparatus[9].

Procedure

By day one, (Acquisition) rats had free access to either the light or dark compartment of the box. In the second day, (Training) rats were placed in the illuminated compartment and 30 seconds later, the guillotine door was raised. After entering the dark compartment, the door was closed and a 1.5 MA (Mili Ampere) constant current shock was applied for 2 seconds. For testing short-term and long-term memory, 48 hours after passive avoidance response training, the rats were put in illuminated chamber and 30 seconds later the guillotine door was raised and the latency of entering the dark compartment and the time spent there during 5 minutes was recorded[14] and this procedure exactly repeated again 30 days after passive avoidance response training for testing long–term memory.

Statistical analysis

Data analyzed by one way analysis of variance (ANOVA) followed by the multiple comparison test of Tukey–Kramer and presented as Mean ± Standard error (SEM). In all cases $P< 0.05$ was taken as statistically significant.

Result

There was significant ($P<0.05$) difference between mothers received $ZnCl_2$ -100mg/kg/-day on step-through latency 2 day (48 hour) after trainingat the stage of lactation and control group (Fig.1).

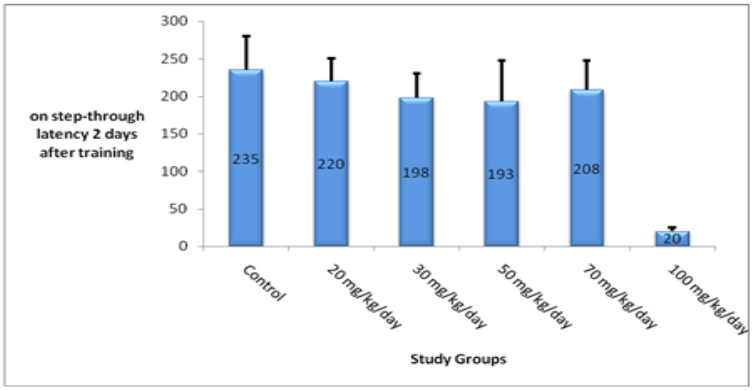

Fig. 1: Effect of different doses ofzinc chloride(study Group) on step-through latency 2 day (48 hour) after training.*$P<0.05$, n=8

However 30 days after training there was no significant difference between control group and any other groups of rats whose mothers received different doses at the stage of lactation (Fig. 2).

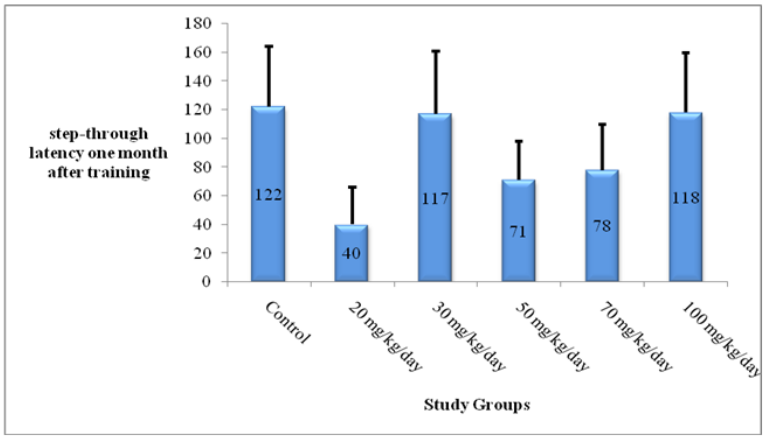

Fig. 2: Effect of different doses ofzinc chloride (study Group) on step-through latency **one month after** training. *P<0.05, n=8

Discussion

Zinc is essential for the early postnatal development of brain. In the present study groups of lactating rats consumed drinking water in five different doses of $ZnCl_2$ for two weeks during lactation. A month after birth, a shuttle box was used to examine short-term and long-term memory of their offspring (Fig. 1& 2). Result is similar to the result of other investigators[7,8]which reported that zinc deficiency during prenatal and postnatal periods associated with impaired maturation and differentiation of cerebellar neurons, impaired learning and memory too[15].

Zinc is necessary for the formation of vesicular zinc in the cerebral cortex and hippo camp to help skill of learning. As matter of fact, zinc concentration in presynaptic vesicle-zinc containing neurons-decrease by the zinc deprivation[16]. The LTP (long-term potentiation: a cellular mechanism memory) induction at the mossy fiber-CA3 synapses regulated by the release of zinc and by the subsequent entry of zinc into postsynaptic neurons[1,17]. Some evidence showed that zinc deficiency impaired calcium channels causing a decrease in intracellular calcium-suppression-gene expression of growth factors involved in synthesis of nucleic acids and proteins[18]. Zn intake is necessary during lactation to ensure proper brain development, and even the mild maternal Zn deficiency result increased Zn influx into the brain[10]. Some scientists reported that enhanced zinc consumption caused memory deficits and increased brain levels of zinc. It is shown that the influx of toxic amounts of zinc to post-synaptic neurons was mainly responsible for the neurodegenerative process[19].

Conclusion

Zinc could not affect long-term memory with 100 mg/kg/day of zinc chloride consumption.

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Competing interests

The authors declare that there is no conflict of interest.

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