Research Article Open Acces

Keywords: Protein malnutrition; Cadmium; Behavioral aberrations; Albino rat

Introduction

e wide–spread environmental occurrence of Cd increases the risk of exposure to it, in organisms during their vulnerable stages of development. Further, the toxic e ects of environmental insults sustained during the embryonic development, are likely to be revealed during the immediate postnatal and even in the late adult life. Ali et al. [1] have investigated the developmental and behavioral toxicity of gestational exposure to low levels of cadmium (Cd 4.2 and 8.4µg/ml, in drinking water) in rats. Signi cant decreases in birth weight and growth rate were observed in the 8.4 µg/Cd/ml group. e metal exposure had no e ect on the ontogeny of Physical landmarks, surface and air righting re exes and visual placing, but a signi cant hyperactivity and delay in the development of Cli aversion and swimming behavior were observed in the neonatal pups of either treatment group. Marked decreases in the locomotor activity and shuttle box performance were evident at 60 days but not at 90 days of postnatal life.

M. Mohamed Ali et al. [2], gave cadmium (Cd, 100 ppm, through drinking water for 60 days) to growing male rats, maintained on diets containing 21, 8 and 5% protein. Cd exposure in the 21% protein diet fed rats resulted in decreased body weight and growth, spontaneous locomotor activity and learning ability. e response latency in the learning situation was enhanced signi cantly. e decreases in the locomotor activity and learning ability were more marked in the 5% protein diet fed animals. e increase in the response latency was, however, more marked in the 8% protein diet fed group. e study indicates the enhanced vulnerability of protein malnourished animals to the behavioral de cits induced by Cd.

Assessment of the e ects of cadmium on locomotor activity and learning performance in growing rats has been reported [3]. e same authors in another study fed low levels of cadmium (4.2 and 8.4 µg/ml) in drinking water to rats and concluded with the data that cadmium exposure during the critical periods of development might result in developmental and behavioral de cits with long term implications on adult behavior.

Alteration in antioxidant defense system in the rat testes was found with Cd exposure [4]. Studies showed toxic nephropathy might be detectable in an early stage by assay of the enzymes in urine. C exposure leads to decrease in glutamate, aspartate, glutamine, GABA and taurine content of rat striatum [5]. Cadmium chloride (CdCl2), administered during gestation period on female wistar rats resulted in decrease in body weight gain and induced hepatotoxicity [6].

Another major factor which has to be taken into consideration in assessing the toxicity of environmental pollutants is the increased vulnerability of the young and immature organisms to the toxic e ects of these toxicants. Clinical and experimental studies have shown that children are more susceptible to the toxic e ects of heavy metals like Pb and Hg [7,8] and the toxicity of Pb, Mn, Hg, polychlorinated biphenyls and diazepam are more pronounced in the prenatal and neonatal phases than in adulthood [1,9-13]. Hence, it is essential to assess the toxicity of environmental pollutants in the adult as well as the young developing organisms. Human and animal studies have shown that protein malnutrition causes reduction in the brain development

ese indices were calculated as follows:

$$\text{Viability Index} = \frac{\text{No. of pups alive at 4 days u}}{\text{No. of pups born alive}}$$

$$\text{Viability Index} = \frac{\text{No. of pups alive at 21 days u}}{\text{No. of pups alive at 4 days}}$$

Morphological development: From birth the pups were observed for the appearance of fur onset, eye opening, pinna detachment and incisor eruption.

(a) Fur onset: Each pup was held in the air against light and screened closely for the appearance of the ne downing hair [25].

(b) Eyeopening: e criteria for eye opening was the appearance of a perceptible break in the supra-ocular membrane and the age at which both the eyes opened were recorded [26].

(c) Pinna detachment: e pups were observed daily until both pinnas on all test pups were detached [27].

(d) Incisor eruption: e pups were observed daily until both upper and lower incisors had erupted in all test pups [27].

Surface righting: It tests motor and vestibular integration. is test was initiated on postnatal day 3. e pups were placed on their back held momentarily and then released. Criterion was achieved when the rat was able to attain a fully prone position within 2 sec. three successive times [28].

Air righting: It tests motor and vestibular integration. From day 10 of age until appearance of criterion response a neuromuscular test using a gravity stimulus was administered to the pups [29]. e pups were dropped from a height of 30 cm above some wood shavings. Each pup was given three trials per day and criterion response was two or

(i)	Direction –	(a)	Straight–3
		(b)	Circling–2
		(c)	Floating–1
		(d)	Sank–0
(ii)			

(ii) Morphological development

[redacted]set: e day of appearance of the downing hair did not [redacted]y in any of the groups (Table 3).

[redacted]detachment: e dietary and Cd exposure schedules [redacted]the day of pinna detachment of the pups (Table 3).

[redacted]ening: e low protein diet schedule had no signi cant [redacted]y of eye opening but it was signi cantly delayed in the [redacted]osed, malnourished dams without any signi cant e ect [redacted]iet–fed counterparts (Table 3).

[redacted]eruption: e dietary and Cd exposure schedules had [redacted]ct on the day of incisor eruption in the pups (Table 3).

[redacted]righting:

[redacted]atistically signi cant e ect on the development of [redacted]re ex in any of the groups was observed (Table 4).

[redacted]ng:

[redacted]uration on the air righting re ex was not signi cantly [redacted]f the groups (Table 4).

[redacted]acing:

[redacted]i cant delay in the development of the visual [redacted]e was observed only in the pups of the Cd–exposed, [redacted]ams (Table 4).

[redacted]sion:

A signi cant delay in the maturation of the cli aversion response was observed in the pups of Cd–exposed dams of both the dietary groups but the e ect was more marked in the protein malnourished group (Table 5).

(vii) Swimming behavior:

e maturation of the swimming behavior, as judged by the direction as well as the head angle was signi cantly retarded in the pups of Cd–exposed dams of both the diet groups but the e ect was more marked in the malnourished group especially on the head angle scoring (Table 5).

(viii) Ascending wire mesh:

A signi cant delay in the development of the criterion response in the ascending wire mesh test was observed in the pups o Cd–exposed malnourished dams only (Table 6).

(xi) Balance beam test:

e development of the beam balancing ability was signi cantly delayed in the pups of Cd–exposed dams of both the diet groups but the e ect was more marked in the protein malnourished group (Table 6).

(x) Day of diet ingestion:

e dietary and Cd–exposure schedules had no signi cant e ect on the day of diet ingestion, (Table 6).

Discussion

In the present study, the low protein diet (8%) caused a signi cant reduction in the litter size, a delay in the physical developmental landmarks like less body weight and eye opening, and also caused marked delay in the development of sensory–motor re exes like visual placing, cli aversion, in the F1 o spring. e viability and lactation indices were not signi cantly a ected.

ere is no doubt that protein malnutrition has a very prolonged e ect on the behavioral and developmental patterns. Malnutrition imposed during the lactation period on young growing mammals by either food restriction of the administration of a low protein diet signi cantly delays the development of various psychomotor re exes [34-36]. In the rat, development indices such as eye and ear opening, grasping re ex, rearing re ex and righting re ex are all signi cantly delayed. Under nutrition imposed during the gestation period by feeding a very low protein diet (5% casein) has been shown to produce a signi cant depression in the ontogeny of various psychomotor re exes in the o spring, in the mice [37] and, in the rat, [34,35,38,39]. e lack of e ect of the 8% protein diet employed in the present study, on the viability and lactation indices might be due to the moderate level of protein de ciency induced.

e prenatal exposure to cadmium had no signi cant e ect on the number of pregnancies, litter size and mortality in the rats of either dietary regimen. Also, it had no signi cant e ect on the physical developmental landmarks like fur onset, pinna detachment, and incisor eruption. Such e ects on the developmental indices have also been reported with other environmental neurotoxic metals like lead [40],manganese [41] and tin [42]; pesticides like diazenon [9], carbofuran [43], Kepone [11], maneb [44] and industrial solvents like t-butanol [45] and carbon disulphide [46] etc.

In the present study cadmium at la low dose level did not cause any signi cant e ect on diet consumption in either dietary group of Fo–rats during the growing, gestational and lactation periods. Cadmium concentration, as low as 1 ppm in drinking water, has been reported to cause aversiveness in rats [47]. In our current study, the water intake in the cadmium exposed dams was lower than that of the controls but the di erence was not statistically signi cant at any time of exposure. e reason for this anomaly is not clear. e lower body weight, smaller size and the resultant body surface area might be a possible reason.

e cadmium intake in the malnourished animals calculated on body weight basis, did not di er signi cantly from that of the normal protein diet fed rats which correlates well with the water consumption data.

e growth retarding e ect of cadmium is well documented. An

Citation: