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Umbilical cord blood lead levels and neonatal behaviour

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Negative correlations have been found between cord blood lead levels and scores on the Brazelton Neonatal Behaviour Assessment in 30 otherwise healthy newborns. Items in the Habituation, Orientation and Regulation of state clusters, particularly those items related to self-regulatory, self-quieting and auditory habituation, showed lower scores (worse performance) in those newborns with higher cord blood lead levels. These disturbances are potentially important since this type of behavior may interfere with the normal process of adaptation to their environment, leading to a less than optimal bonding between newborns and their carers.

Keywords: Behavior – Child behavior – Environmental health – Infant newborn – Infant newborn diseases – Lead – Lead poisoning – Umbilical cord

INTRODUCTION

Lead has been used in ceramic work for longer than 7000 years; it was known to the Phoenicians and Roman culture, and symptoms of chronic lead poisoning were known at that time. In 1943 Byers and Lord published their observations on the negative sequelae of lead intoxication. Since then there have been a number of papers on the effects of lead on infant and child development, particularly in recent years, prompted by general concern about the widespread use of leaded gasoline in the growing number of motor vehicles.

The effects of lead on the mental development of North American children was studied by Needleman (Needleman *et al.*, 1979; Needleman, 1985), who found a negative correlation between school performance and WISC scores, and the levels of lead in dental tissue of children. Yule and Rutter (1985) carried out research on the effects of lead on behavior and cognitive performance of British children with similar results. The Port Pirie Cohort Study results (Baghurst *et al.*, 1992) showed lower IQ scores in children with moderately elevated blood lead levels. Bellinguer *et al.* (1991) studied the cognitive function of young pre-school children and found some disturbances in visual–spatial or visual–motor coordination in those exposed to lead. Overall, there is a general agreement that lead has deleterious effects on children's brains, although some researchers take a different view. For example, Smith *et al.* (1983) found no significant differences in the performance of children with high, intermediate or low lead levels, and some investigations showed that no peripheral nerve pathology occurs at low blood lead levels (Cooney *et al.*, 1989). A study carried out in California in which umbilical cord blood levels were measured showed a direct correlation between prematurity and blood lead levels over 55 μg/dl (Satin *et al.*, 1991).

This study was designed to evaluate possible short-term neurobehavioral consequences for the newborn exposed to lead *in utero* at levels that, today, are regarded as safe.

METHODS

Thirty healthy newborns (13 girls and 17 boys) were recruited for the study on a consecutive basis after parental consent was obtained. In order to be eligible, they had to be full term (37-42 weeks of gestational age), with no history of fetal distress (Apgar score over 7 at 1 min of age) and not requiring medical care other than the routine care for a healthy full-term newborn. Special emphasis was put on ascertaining that the mothers had no medical problems in their history; therefore newborns of mothers with a history of smoking, alcohol drinking or other drug use were excluded.

Lead levels were measured in cord blood specimens. Cord blood samples were obtained in the delivery room, collected in plastic tubes with heparin-lithium as anticoagulant, and kept in the refrigerator at 4 °C until processed. Lead levels were measured by atomic absorption spectrophotometry and processed in the Laboratory of Toxicology at the hospital clinic of the University of Barcelona.

The Brazelton Neonatal Behaviour Assessment (BNBAS) was used to evaluate neurobehavior of the neonate as described by Brazelton (1984). The scale was always administered between the 60th and 80th hour of life. The BNBAS was performed by an examiner trained for reliability in the administration and scoring of the scale at the Children's Hospital of Boston, Massachusetts, and blind to the blood lead levels of the newborns.

The scoring system used was developed by Lesler *et al.* (1982) and combined the 26 behavioral items into six 'clusters', i.e.: habituation, including decrement of responses to repeated visual, auditory and tactile stimulation; orientation, including auditory and visual orientation to inanimate objects as well as responsiveness to the examiner's voice and face; motor performance, including tone, vigor of movements and head control; range of state, referring to the lability of movement from one state to another; regulation of state, referring to how the infant controlled his own state; and autonomic stability, referring to signs of physiological stress seen during the examination, such as startles, tremors and changes in skin color. The seventh cluster referred to reflexes, and was not used because these should have been normal by definition in this sample selection.

Statistical methods

The degree of association between cord lead level and neonatal behavior was evaluated by the *t*-test for correlation using the Microstat computer program. As an alternative method of analysis, a comparison of BNBAS cluster scores was carried out after the subjects were classified into two subgroups according to their lead levels (above or below the median). Mean BNBAS scores in both groups were compared and significance of differences evaluated by a two-tailed *t*-test for difference between means.

RESULTS

Cord blood lead was detected in all subjects: the frequency distribution ranged from 1.9 to 15 μg/dl (mean 6.48, median 5.8, S.D. 3.24).

Comparing the sex ratio, gestational age, Apgar scores and somatic characteristics of the infants with lead levels above or below the median (5.8 μg/dl), no significant differences were observed between the two groups (Table I). However, significant differences were found when comparing the BNBAS clusters scores of the groups (Table II). The correlation between lead levels and the six clusters is presented in Table III. Habituation, orientation, regulation of

TABLE I. Comparative analysis of infants in the study

	Cord blood lead level	
	> 5.8 μg/dl Mean (range)	< 5.8 μg/dl Mean (range)
Blood lead (μg/dl)	9 (6-15)	3.96 (1.9-5.6)
Birth weight (g)	3248	3508
Length (cm)	50.2	49.26
Head circumference (cm)	34.78	34.26
Ratio M/F	1.5	1.1
Gestational age (weeks)	40.1	39.2
Apgar 1 min	(8-10)	(8-10)
Apgar 5 min	(9-10)	(9-10)

TABLE II. Comparative analysis of the BNBAS cluster mean scores of infants in the study

	Cord blood lead level		*p*
	> 5.8 μg/dl (mean)	< 5.8 μg/dl (mean)	
Habituation	5.10	6.43	0.01
Orientation	4.79	5.87	0.05
Regulation state	4.28	5.58	0.01
Motor performance	4.85	5.30	0.05
Range of state	4.18	4.63	NS
Autonomic stability	5.74	6.43	0.05

TABLE III. Correlation coefficient between lead levels and BNBAS cluster scores

	r	*p*
Habituation	−0.65	< 0.01
Orientation	−0.43	< 0.05
Regulation of state	−0.60	< 0.01
Motor performance	−0.30	N.S.
Range of state	−0.46	< 0.01
Autonomic stability	−0.44	< 0.05

state, range of state and autonomic stability clusters showed a statistically significant negative correlation with cord blood lead levels.

DISCUSSION

Previous work on lead toxicity to the CNS of children was either cross-sectional, where lead concentration in specific tissues (teeth, hair) was correlated with mental development, or based on the follow-up of the children's blood lead levels over a period of time and subsequent mental evaluation of those children. Findings in those investigations are variable and of questionable clinical significance. Baghurst *et al.* (1992) found lower IQ scores in 4.4-5.3% of children with blood lead levels between 10 and 30 μg/dl. Bellinguer *et al.* (1991) found disturbances in visual–spatial or visual–motor coordination, in children with blood lead levels as low as 6.8 μg/dl; however, these disturbances were not present 57 months later, when children had blood lead levels of 5 μg/dl. Similarly, Cooney *et al.* (1989) found no disturbances at the age of 5 years when blood lead levels were below 8 μg/dl. More recently, Dietrich *et al.* (1993) found fine motor disturbances in 6-year-old children who had low blood levels when born (4.8 μg/dl), but whose blood lead levels had increased up to 17 μg/dl by the age of 2 years. A study carried out by Bellinguer *et al.* (1992) found poorer cognitive and school performance scores in 10-year-old children who had blood lead levels above 10 μg/dl by the age of 2 years.

It is well known that lead easily crosses placental and CNS barriers (Goyer, 1990). It is also possible that fetal and neonatal neural tissue is more sensitive to lead toxicity, but there are few studies correlating cord blood lead levels (or maternal blood levels) with disturbances in neonatal behavior.

Behavior scores of neonates evaluated in this investigation can be considered within the normal range. However, newborns with higher cord blood lead levels showed lower scores in habituation, orientation and regulation of state clusters: they seemed to have more difficulty in self-quieting, self-regulatory activity and lower habituation to auditory stimuli. These disturbances are potentially important for the future mental development of the newborn, despite the lack of readily noticeable symptoms in the routine physical examination of these newborns during their early days of life, other than by using very sensitive methods such as the BNBAS. The type of behavior observed in those newborns with higher cord blood lead levels may interfere with adaptation to their environment, leading to a less than optimal bonding between newborns and their carers.

We conclude that there is a negative correlation between cord blood lead levels and behavior scores of the neonate as measured with the BNBAS.

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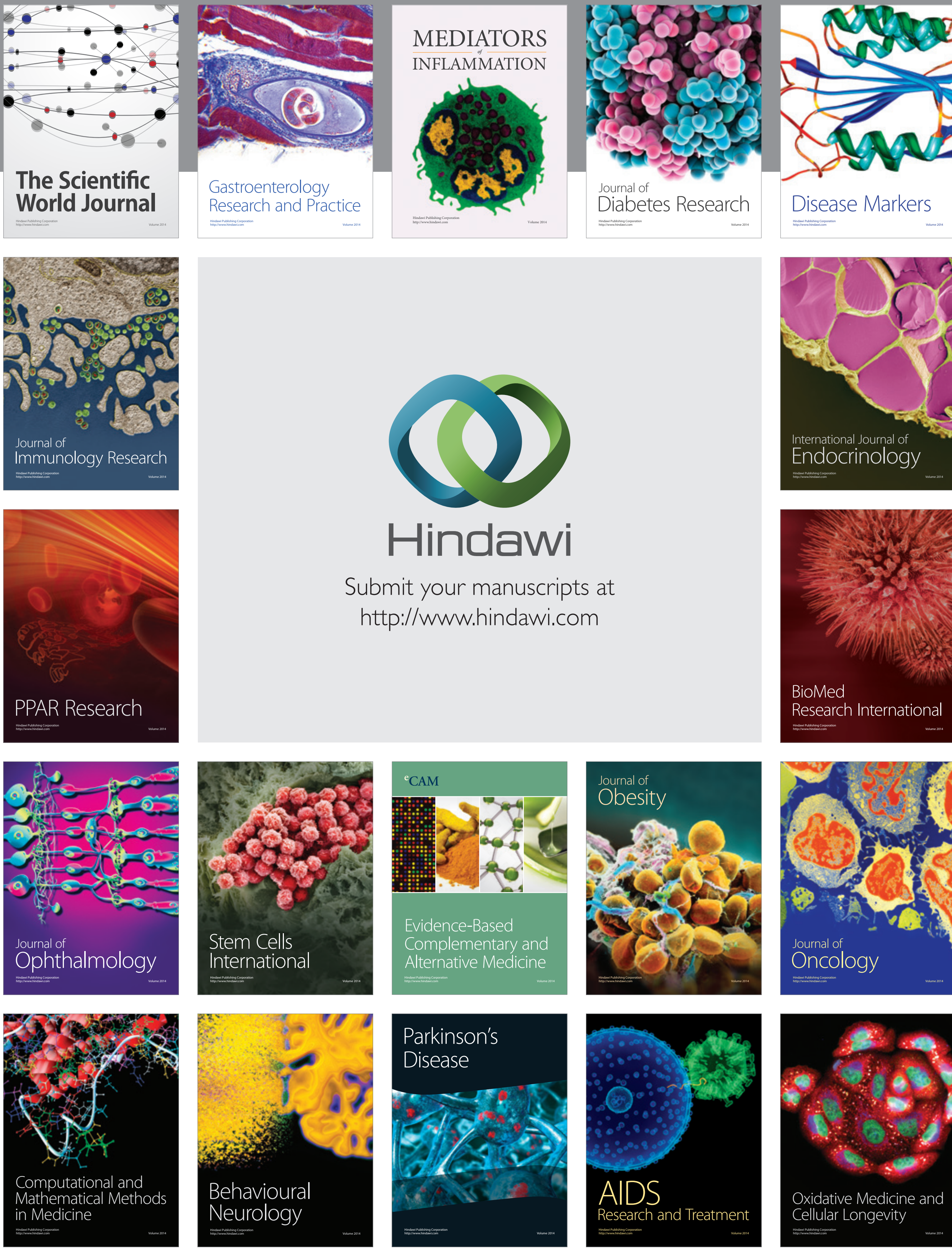

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