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Rev Chil Pediatr. 2019;90(3):275-282
DOI: 10.32641/rchped.v90i3.690

ORIGINAL ARTICLE

Psychomotor development and cortisol salivary levels in infants that live with their inmate mothers

Desarrollo psicomotor y cortisol salival en niños que viven juntos a sus madres privadas de libertad

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Received: 5-4-2018; Approved: 15-12-2018

Abstract

In Chile, the prison system has a program that allows inmate mothers to live with their children under two years of age. This could imply that these children are more exposed to stress conditions and a higher psychomotor developmental delay (PDD) risk. **Objective:** To compare the PDD and salivary cortisol concentrations (SCC) of children living in prison with their mothers and to compare the results with control children. **Subjects and Method:** Cross-sectional study in 42 infants, 12 of them are children of inmate mothers in the penitentiary center (CPF) of Santiago, and 30 controls from a Primary Care Family Health Center (CESFAM). PDD of infants was assessed through the ASQ-3 questionnaire and salivary cortisol was measured in infants and mothers using radioimmunoassay. **Results:** The median salivary cortisol level of the children of CPF and CESFAM mothers was 2.3 ng/ml (IQR 1.1 to 2.7) and 2.1 ng/ml (IQR 1.6 to 2, 9) respectively. Maternal cortisol was 4.6 ng/ml (IQR 3.8 to 7.3) in the CPF and 3.7 ng/ml (IQR 2.4 to 4.7) in the CESFAM. The PDD deficit was 2.3% and 28.5% for children from the CPF and the CESFAM respectively, without statistical difference (p = 0.06). **Conclusions:** There was no difference in the PDD and salivary cortisol between children of both groups.

Keywords:
Psychomotor development;
stress;
infants;
cortisol;
saliva;
penitentiary center;
family health center

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How to cite this article: Rev Chil Pediatr. 2019;90(3):275-282. DOI: 10.32641/rchped.v90i3.690

Introduction

Psychomotor development (PMD) is the skill set that the child achieves through the maturation of the Central Nervous System and interaction with the environment, setting the foundation for children's future learning[1]. The estimated PMD delay prevalence in Chilean children treated in the public health system is lower than that observed in industrialized countries (11% vs. 12 to 16%, respectively)[2,3]. It is noteworthy that the data from the Department of Statistics and Health Information (DEIS)obtained from the Monthly Statistical Summaries (REM, Resumenes Estadísticos Mensuales) 2016, show that the prevalence of PMD delay varies between 2 and 7% in children under 2 years old[4]. It is possible that there is a sub-register related to the use of PMD screening tests used in our country: *Escala de Evaluación del Desarrollo Psicomotor* (Psychomotor Development Evaluation Scale; EEDP in Spanish), and Psychomotor Development Test (TEPSI).

In recent years new screening instruments have been developed based on reports from parents or primary caregivers, such as the Ages and Stages Questionnaires (ASQ), which is being widely used in the USA and other countries. This instrument has also been validated in Chile[1,5,6] with the Bayley scale in its Spanish version. Ages and Stages Questionnaires showed a sensitivity and specificity of 73% and 81% respectively when compared to the Bayley scale, a test considered gold standard[5].

On the other hand, it is known that there are different environmental and social factors that can influence the children's development, one of these is stress, having evident effects on neurodevelopment in the first years of life[7,8].

One of the ways to evaluate the stress degree is to measure salivary cortisol levels, a steroid hormone produced in the hypothalamic-pituitary-adrenal (HPA) axis that is secreted in saliva as a reaction to stress, for which it has been used as a biomarker of stress in the adult and pediatric population[8]. There is ample evidence that the use of salivary cortisol correlates significantly with total cortisol (plasmatic)[9,10].

Observational studies suggest that early life stress is associated with cognitive deficits and elevated cortisol levels in children[11-13]. In addition, there is evidence that young children who maintain high cortisol levels show lower cognitive performance[14-16].

Among other environmental factors that can influence neurodevelopment is deprivation of maternal contact, poverty, and other social conditions[17-19]. Early separation due to maternal imprisonment breaks the attachment bond and can have a harmful impact on a developing child, which has been described by some experts as a 'lasting trauma'[20-24].

Currently, in Chile, women represent 10% of the prison population, 95% of them are mothers and 2/3 have underage children[25,26]. Life in prison is complex. Women who live there with their children have to adapt to very rigid discipline and often the living conditions are far from being the most adequate (e.g. overcrowding, lack of hot water and heating). In general, these are young women, the vast majority have not completed secondary education and have lived their entire lives with deprivation. Mothers are often exposed to stressful situations: they cannot accompany their children to the doctor if they become ill, they have to face trial and inspections, and they often have a scarce social support network outside prison[27].

In this context, and in accordance with the protection and promotion principle of the rights of the child, Chile facilitates contact between mothers in prison and their children in a section of the prison, where mothers are allowed to live with their children during the first two years of life. At the same time, in some centers such as the San Joaquin Penitentiary Center, there is also a *Fundación Integra* (Chilean foundation, main pre-school education provider) program that provides a nursery system for the children of the inmates. At present, there are no studies that analyze the psychomotor development evaluation of these children. The objective of the study was to describe the PMD and salivary cortisol concentration (SCC) of children living in prison with their mothers and to compare the results with those observed in children who are not on this regimen.

Subjects And Method

Study design

Cross-sectional study that included all children under 2 years of age without acute pathology who lived with their mothers in the San Joaquín women's correctional center (WCC), and a group of children, matched by age, enrolled in the "Padre Vicente Irarrázaval" Primary Care Family Health Centre (CESFAM) in the commune of Estación Central, which belongs to the public health system. The exclusion criteria were children who presented pathologies that could negatively influence the PMD, hospitalizations longer than one month, and whose mother did not have a command of the Spanish language.

At the beginning of the evaluation, maternal age, the following data were recorded: time spent in the WCC, perinatal pathologies, drug use during pregnancy, gestational age at birth, breastfeeding, mother's schooling, and presence of acute illness of the mother and/or child.

The following variables were considered dependent

on PMD: salivary cortisol levels in children and variables independent of sex, chronological age of the child, level of maternal salivary cortisol concentrations, nutritional status of the child, educational level reached by the mother and maternal age.

Tools used for measurement

Psychomotor development: ASQ-3 was used to evaluate children's PMD. This test is a screening instrument for children from 1 month to 5 years old, which consists of five domains (communication, fine motor skills, gross motor skills, problem solving, and interpersonal relationships). The corresponding test was used according to the chronological age of the children and in the case of preterm infants, according to the corrected age. As for the application of the test, each child was evaluated only once and his/her mother was the one who answered the questions. Explanatory accessory material was used and help was given to answer the questionnaire when the mother had doubts regarding the milestone reached.

There is no consensus in the literature on what criteria to use for defining psychomotor developmental deficit. Most of the authors recommend relying on domains, considering PMD deficit cases that have at least one lowered area with a score lower than -2SD of the average. This proposal was which we considered for carrying out our study.

In Chile, the 8, 18, and 30 month questionnaires were validated. In a preliminary analysis, it was demonstrated that the use of cut-off values from the original USA validation were applicable to our population, so for this study the published cut-off points were used, considering as a PMD deficit risk having at least one area below the cut-off points[29,30].

Cortisol measurement. The salivary sample for cortisol measure was taken from children and mothers between 8:00 am and 11:00 am. Mothers confirmed that they and her children had not received food at least one hour before[31]. The samples were taken with a cotton swab, collected in an Eppendorf tube, and stored at -20 º C until they were processed in a blinded fashion. They were thawed and centrifuged for five minutes at 3000 rpm, and the supernatant was used to determine salivary cortisol by radioimmunoassay using a commercial kit (DIAsource ImmunoAssays S.A.). The method sensitivity is 0.5 ng/ml and the intra- and inter-assay variation coefficients are 5.5% and 10.6% respectively. Reference value: 1.2-7.5 ng/ml

Given the known variability of cortisol secretion, it was used the mean result of two salivary cortisol samples obtained from the same subject on different days but in the same hourly range.

Nutritional status of the infant. The weight was recorded in kilograms using a previously calibrated weight scale, and the height in centimeters using a portable stadiometer. Nutritional assessment was carried out using W/A, W/H, and H/A indicators according to WHO reference tables, classifying nutritional status according to international cut-off points[32,33].

Sample size. Since the study evaluated all infants who were living in that moment with their mothers in the WCC, and there are no national publications referring to salivary cortisol concentration in Chilean infants, no sample size calculation was performed.

Statistical Analysis

Descriptive data were reported using absolute and relative frequency tables for qualitative variables, and quantitative variables were expressed through median and interquartile range (IQR) or mean, and standard deviation according to their distribution. The Fisher and Mann-Withney tests were used to evaluate the significance of the association, considering significant a $p < 0.05$ value. Data were processed and analyzed using the STATA 15 Software.

Ethical Committee

This study was authorized by the Metropolitan Regional Directorate Technical Unit of the Chilean Gendarmerie and approved by the Ethics Committee of the Central Metropolitan Health Service. Each mother signed an informed consent form before the application of the study.

Results

Between August and December 2017, 48 children between the ages of 1 and 24 months were recruited**.** 13 infants entered the case group (1 dropped out of the study), and 30 entered the control group. All the children who entered the study were Chilean, only one mother was Peruvian. The median chronological age of the children was 7 months (IQR 5- 11 months). In 90.5% of the children, the gestational age was higher than or equal to 37 weeks. There was male dominance. All the children in the WCC received breastfeeding at some time and only almost half of the children did so at the CESFAM (100% vs 45.2% respectively, $p = 0.01$) (Table 1). In terms of the nutritional assessment of children, 71.4% were eutrophic, 23.7% present malnutrition by excess, and only one child was at risk of undernutrition. We found no differences when analyzing nutritional status provided by both locations.

Although all mothers could read and write, the educational level was lower among mothers in the

WCC (p=0.03). In addition, 30% of mothers had some pathology during their pregnancy which was significantly more frequent (58%) in the WCC mothers (p=0.01). The most frequent pathologies were hypertensive pregnancy syndrome (9.5%), and gestational diabetes (9.5%) (Table 2).

The median salivary cortisol level in children of the sample was 2.1 ng/ml (IQR 1.2 to 1.8), with no significant differences between children of the WCC and those of the CESFAM (2.3 ng/ml IQR 1.1 to 2.7 vs 2.1 IQR 1.6 to 2.9, respectively). Regarding maternal salivary cortisol level, the median was 3.8 ng/ml (IQR 3.0 to 5.3) with no significant difference between inmate mothers and those of the CESFAM (Table 3).

After measuring PMD using ASQ3, we observed that 13 children had PMD deficits, 61% of them had more than one altered domain, and the areas at the highest risk were fine and gross motor skills, and problem solving. When performing the PMD analysis, according to the child's residence, we found that the PMD deficit was more frequent among children living outside the WCC representing 2.3% vs 28.5% respectively (Fisher Test p = 0.06) (Table 4). Out of the total number of children in the sample, four children were younger than 37 weeks, and only one of these had a PMD deficit.

When comparing the salivary cortisol concentration of children according to the PMD and the salivary cortisol values of mothers with the PMD, no significant association was found (Table 5). We also found no differences when assessing the relationship between the child's PMD and maternal educational level, regardless of the child's residence.

Table 1. Demographic characteristics of children by group of study

	CPF (n = 12)		CESFAM (n = 30)		Total (n = 42)	
	Median	IQR	Median	IQR	Median	IQR
Age (months)	7	7-11	6	4-15	7	5-11
	Media	DS	Media	DS	Media	DS
Weight/age (z)	0.2	0.6	0.4	0.7	0.3	0.7
Height/age (z)	-0.9	1.0	-0.3	1.0	-0.4	1.0
Weight/height (z)	0.9	1.0	0.8	0.9	0.8	0.9
	n	%	n	%	n	%
Gestational age						
< 37 weeks	1	2.3	3	7.1	4	9.5
≥ 37 weeks	11	26.1	27	64.2	38	90.5
Sex						
Male	8	15.3	14	33.3	22	52.0
Female	4	9.5	16	38.0	20	48.0
Breastfeeding	12	28.5	19.0	45.2	31	73.8

n= sample size, % = percentage of sample size total; CPF: Prision, CESFAM Primary Care Center. IQR; Interquartile range.

Table 2. Nutritional status of children by group of study

	CPF		CESFAM		Total		p
	n = 12 n	(28%) %	n = 30 n	(71%) %	n = 42 n	(100%) %	
Nutritional status							**0.72**
Malnutrition	0	-	0	-	0	-	
Risk of malnutrition	0	-	1	3.3	1	2.3	
Normal	10	83.3	21	70.0	31	71.4	
Overweight	1	8.3	6	20.0	7	16.6	
Obesity	1	8.3	2	6.6	3	7.1	

CPF: Prision, CESFAM: Primary Care Center.

Table 3. Demographic characteristics of mothers by group of study

	CPF n = 12		CESFAM n = 30		Total n = 42	
	Median	IQR	Median	IQR	Median	IQR
Age (years)	24. 0	25-33	25.5	23-30	26.0	24-30
Education* (n y %)						
Illiterate	4	9.5	3	7.1	7	16.6
Primary	6	14.2	4	9.5	10	23.8
High school	2	4.7	19	45.2	21	50.0
Above high school	0	0	4	9.5	4	9.5
Pregnancy disease*						
Present	7	16.6	6	14.2	13	30.9

n = sample size, % = percentage of sample size total; CPF: Prision, CESFAM Primary Care Center, IQR; Interquartile range; *(test Fisher's $p < 0.05$).

Table 4. Salivary cortisol concentration by group of study

	CPF n = 12		CESFAM n = 30		Total n = 42	
	Median	IQR	Median	IQR	Median	IQR
Salivary cortisol ng/ml						
Children	2.3	1.1 a 2.7	2.1	1.6 a 2.9	2.1	1.2 a 1.8
Mothers	4.6	3.8 a 7.3	3.7	2.4 a 4.7	3.8	3.0 a 5.3

CPF: Prision, CESFAM Primary Care Center, IQR; Interquartile range.

Table 5. Psychomotor development of children by group of study

	CPF		CESFAM		Total		p
	n = 12 n	(28%) %	n = 30 n	(71%) %	n = 42 n	(100%) %	
DSM							**0.06**
Normal	11	26.1	18	42.8	29	69	
Deficient	1	2.3	12	28.5	13	30.9	

CPF: Prision; CESFAM Primary Care Center; DSM: Psychomotor development.

Discussion

The main finding of this study is that children living with their mothers at WCC have salivary cortisol concentrations similar to those seen at CESFAM. In addition, we think it is important to point out that the PMD deficit was strikingly more frequent in CESFAM children, although the difference was not significant ($p = 0.06$), it is possible that this is due to the sample size.

The results of the only study conducted in a population similar to ours differ somewhat from those found by us. Morales M. found in a children sample obtained from the same WCC (n=15), after evaluating the PMD through EEDP, that 25% of children had altered PMD[18]. Since the time of this work publication, there have been changes, such as the creation of the nursery, which could be responsible for the differences found. We believe that the contact of children with their mothers and the stimulation that they received in the WCC kindergarten, could influence the observed results. We think it is important to emphasize that the mentioned kindergarten has, in addition to the regular staff in this type of facility, a psychomotor specialist

and weekly psychological consultation which could enhance the maternal care impact. We also notice the high breastfeeding frequency in WCC children (100%) which could be favored because children sleep with their mothers, a situation promoted by the government program *Crececiendo Juntos*[34] (Growing Together). Regarding the breastfeeding impact on PMD, Chui et al. have shown that there is a linear "dose-response" association between breastfeeding duration and motor and cognitive development[35]. On the other hand, the PMD deficit observed in children treated at CESFAM (28%) is similar to that found in national studies (30%). [36]

The salivary cortisol concentration detected in both groups of children in the study is within the normal range. Tollenaar et al. analyzed the morning salivary cortisol concentration in a cohort of 300 infants by measurements at six weeks, five months, and 10-12 months of age showing that normal ranges in infants younger than one year of age are between 1.59 and 9.05 ng/ml37. Another study carried out by Albers et al. measured salivary cortisol in 64 infants under one year of age in a nursery, determining that normal concentrations were between 1.92 and 4.34 ng/ml[12].

Cortisol, under normal conditions, shows a marked circadian rhythm in adults and children. Cortisol levels are highest in the morning, followed by an abrupt drop immediately after awakening[38-41]. It is believed that infants develop this cortisol circadian rhythm during the first year of life, but exactly when, it has not yet been established. The concentration variability of this hormone, when measured repeatedly, is not clear. A pioneering study by Ivars et al. describes that most infants begin their circadian rhythm at four months of age; however, they describe a significant individual variability of these levels, as shown in our study[42]. It is known that cortisol concentration varies widely in the same subjects at different times of the day and according to age[40]. Other factors, depending on the sampling standardization, could also explain the above-mentioned variation. In our study, the necessary fasting period before sampling (1 hour)[43] was evaluated by questionnaire, which could also explain some of the observed variability.

Regarding the limitations of our study, the small number of evaluated children in the WCC is one of the factors that could explain the lack of significant differences found in our work. Another aspect to consider is that the study design does not allow for causality associations. A future study should consider a control group of children living with their mothers in a penitentiary center without a nursery. We believe that it is also necessary to follow up the evaluated children to explore whether PMD and stress are affected in the long term.

It should be noted that this is the first study in Chile that measure the stress level of mothers and children in a penitentiary center, which includes an interdisciplinary nursery, and its association with the PMD that these children have living under these conditions.

As a conclusion, we believe that our study is a contribution that should be considered when evaluating the benefit of the coexistence between infants and their mothers in penitentiary centers of the country, having the obligation to respect the rights of children.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Financial Disclosure

Authors state that no economic support has been associated with the present study.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Acknowledgement

The authors thank the women who participated in the study and the valuable contributions of staff who work in the kindergarten and Primary Care Center "Padre Vicente Irarrázaval".

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