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Effects of adverse prenatal environments on the physiology and behaviour of the offspring

Carlos Eduardo Hernandez Verduzco

Abstract

Maternal periconceptional nutrition affects growth, metabolism and endocrine development of the offspring into postnatal life. However, the effects on postnatal behaviour are unknown. We investigated the effects of maternal periconceptional undernutrition (PCUN) on three main aspects of offspring behavioural development: establishment and maintenance of a selective ewe-lamb bond, evaluated as bonding behaviours at birth and preference for each other over an alien ewe/lamb; cognitive function, evaluated as reversal learning and behavioural laterality in a maze; and stress reactivity, evaluated as behavioural and physiological response to isolation and an approach/avoidance test to a human. Ewes were well fed throughout pregnancy (controls) or mildly undernourished (10–15% body weight reduction) for 60d before mating, for 30d after mating or for 60d before to 30d after mating. Ewe-lamb bonding behaviours were evaluated at lambing, 24h, 1 and 4 weeks of age. Cognitive function and stress reactivity were evaluated at 4 and 18 months.

Maternal PCUN increased suckling behaviour and reduced the time to first suckle in males, making their behaviour similar to that of females. However, there were no long term effects of PCUN on the ewe-lamb bond, assessed as the preference for each other over an alien ewe/lamb up to 4 weeks of age. Maternal PCUN did not affect reversal learning ability in the offspring but altered behavioural laterality at 4 but not 18 months of age, and these alterations differed by sex and litter size. In response to isolation, maternal PCUN reduced attempts to escape in offspring at 4 months and suppressed plasma cortisol AUC at 18 months of age. Maternal PCUN did not affect offspring behavioural reaction in response to a human. The effects of PCUN were largely independent of the time/duration of undernutrition. These studies demonstrate that maternal undernutrition around the time of conception alters some aspects of offspring behavioural development and has long term effects on stress reactivity and cognitive function. These effects are subtle, independent of birth weight, change with postnatal age, and differ by sex and litter size. Maternal nutrition around the time of conception may have important implications for welfare of the offspring.
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Abbreviations

ACTH  adrenocorticotropic hormone
AUC  area under the curve
AVP  arginine vasopressin
°C  degrees Celsius
CIDR  intravaginal device containing progesterone
cm  centimetres
CRH  corticotropin-releasing hormone
CZ  contact zone(s)
d  days
g  grams
GLM  generalised linear models
h  hours
HPA  hypothalamic-pituitary-adrenal
HSD2  11-ß-hydroxysteroid dehydrogenase type 2
ID  identification number
kg  kilograms
l  litre
LSmean  least square mean
m  meters
mg  milligram


min  minutes

ml  millilitre

ng  nanogram

PCUN  periconceptional undernutrition

pg  picogram

R1  reversal task 1

R2  reversal task 2

REML  restricted maximum likelihood

s  seconds

SEM  standard error of the mean

SGA  small-for-gestational-age

UN-60+30  undernourished from –60 to +30 d from mating

UN-60-0  undernourished from –60 to 0 d from mating

UN-2+30  undernourished from -2 to +30 d from mating