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A longitudinal study of basal cortisol in infants: Intra-individual variability, circadian rhythm and developmental trends

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Abstract

Mothers with normally developing babies were visited in their homes during 13 consecutive weeks, when the babies were around 5–8 months of age. Basal salival cortisol measures were taken for both the baby and the mother on arrival.

The infants' basal cortisol decreased linearly with age, was negatively related to sleep, and did not show adult-like circadian declines from morning to mid-afternoon. Furthermore, while the infants showed relative stability across individuals, they displayed great intra-individual variability across assessments. Contrarily, the mothers displayed important inter-individual variability, together with a relative stability across assessments. The infants' important intra-individual variability was not affected by gender, nor time of visit, nor was it related to the mothers' basal cortisol. Daily measures of basal cortisol taken in a subgroup of infants indicated the day-to-day intra-individual variability to be of the same magnitude as the week-to-week variability.

The question of how the intra-individual variability in basal cortisol affects assessments of cortisol in infancy is addressed. The aggregation of data with the goal of increasing the reliability of the assessments is shown to be inadequate for infant basal cortisol.

Keywords: Basal cortisol; Intra-individual variability; Infants; Circadian rhythm

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1. Introduction

Cortisol is a steroid hormone belonging to the hypothalamic-pituitary-adrenocortical axis. It is secreted in a pulsatile fashion by the adrenal cortex and its levels show a strong circadian rhythm, being lowest around midnight and highest in the early morning hours (Kirschbaum & Hellhammer, 1989).

In recent years, an upsurge in studies of cortisol response has occurred mainly due to two reasons. First, cortisol is a hormone with many different and important functions, which are mainly aimed at regulating circadian-driven activities (de Kloet, Rosenfeld, van Eekelen, Sutanto, & Levine, 1988). Cortisol intervenes in energy release (e.g., liberation of glucose, inhibition of insulin), immune activity (e.g., downregulating inflammatory responses and the cytokine cascade), mental activity (e.g., increased alertness, memorization, learning), growth system (e.g., inhibition of growth hormone), and reproductive function (e.g., inhibition of gonadal steroids) (Flinn & England, 1997). As such, it is an essential hormone for the energy balance in our bodies, producing a broad spectrum of physiological effects as virtually all body cells are affected by cortisol (Kirschbaum & Hellhammer, 1989). Cortisol also plays an important role in stress responses, as it is secreted when the organism faces a difficult or problematic situation that is perceived as stressful.

A second reason for the success in being the object of scientific endeavor is due to practical laboratory developments of the last decades (Kirschbaum & Hellhammer, 1989, 1994). Previously cortisol levels could only be assessed in serum or urine. Currently, cortisol can be easily and reliably assessed in saliva using relatively cheap and ready-made kits (Schwartz, Granger, Susman, Gunnar, & Laird, 1998).

An area that has especially benefited from the technological advances is the study of stress in infants and children. In addition to behavioral and psychological assessments, physiological measures are often added to infant research designs to provide a more objective measure (Spangler & Scheubeck, 1993). Thus, in addition to its physiological importance, the technical accessibility and the popularity of inter-disciplinary studies, have made cortisol a much-measured hormone in developmental studies (e.g., Gunnar, Brodersen, Krueger, & Rigatuso, 1996; Larson, White, Cochran, Donzella, & Gunnar, 1998; Lewis & Ramsay, 1995; Spangler & Grossmann, 1993). Examples of such infant studies are those studying behavioral and hormonal reactions to potentially stressful situations such as maternal separations, inoculations, new situations and physical examinations (Gunnar et al., 1996; Gunnar & Donzella, 2002; Gunnar, Larson, Hertsgaard, Harris, & Brodersen, 1992; Hertsgaard, Gunnar, Larson, Brodersen, & Lehman, 1992; Larson et al., 1998; Lewis & Ramsay, 1995; Spangler & Scheubeck, 1993). Cortisol measures have also been taken during attachment assessments, in which infants are subjected to a potentially stressful event, namely the temporal separation from their caretaker (Goldsmith & Harman, 1994; Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989; Hertsgaard, Gunnar, Erickson, & Nachmias, 1995). One or more measures of cortisol are typically taken after the potentially stressful situation, and then compared to a measure of "basal" or resting cortisol taken before the onset of the situation. This first sample is taken on arrival at the site where the stressful situation will take place. Longitudinal studies of the developmental course of the reactions typically collect two to four consecutive measurements. Given the importance of the basal cortisol level as a point of reference, it is somewhat