

Hair Cortisol as a Biomarker of Long-Term HPA Activity and Stress

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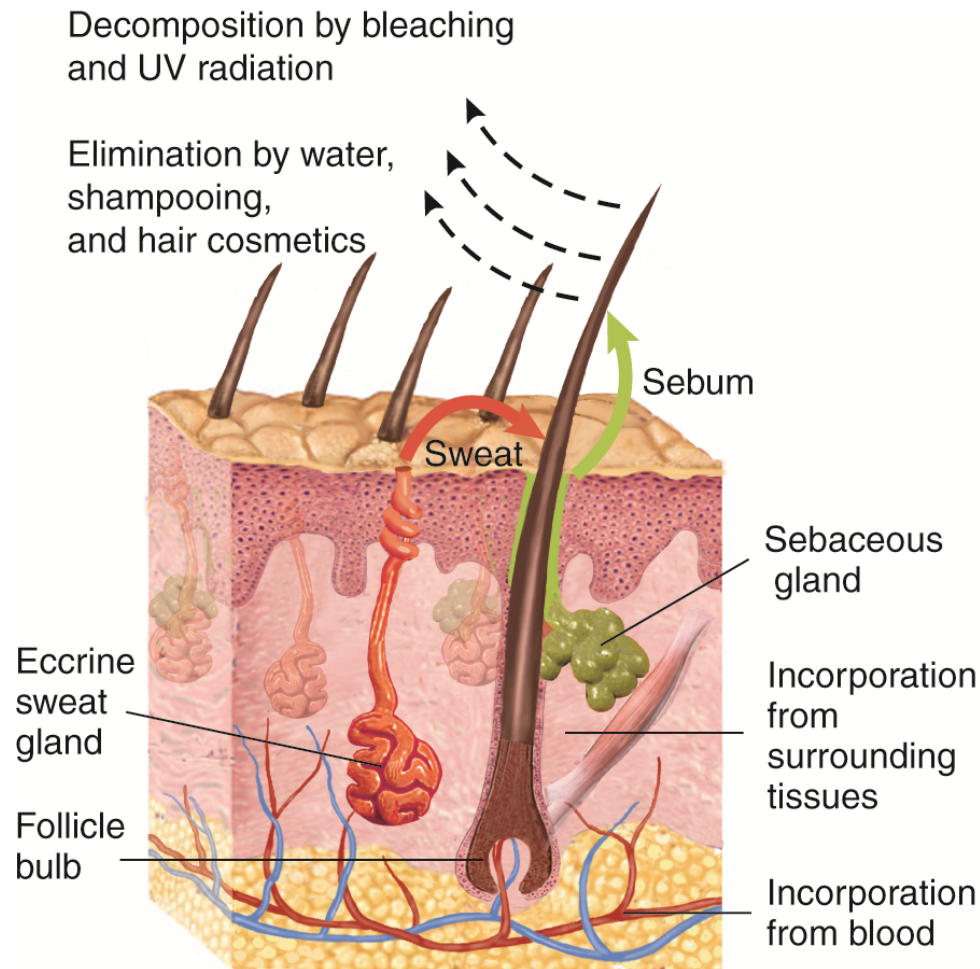
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Comparison of Different Matrices for Glucocorticoid Measurement

	Sample Type	Time Frame	Steroids	Invasiveness	Stability
Blood	point	minutes	total	modest	1
Saliva	point	minutes	free	minimal	2-3
Urine	state	hours/day	free	none	2
Feces	state	hours/day	free	none	2-3
Hair	chronic	weeks/months	free	minimal	5

Potential Mechanisms of Cortisol Incorporation and Elimination in Hair



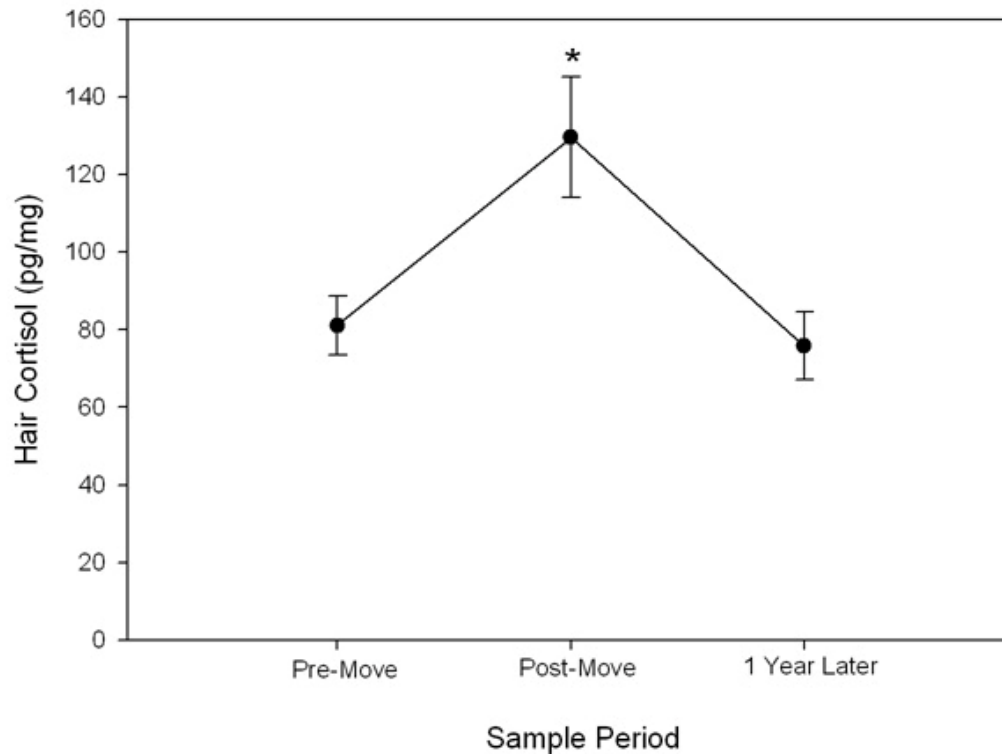
Methodology of Hair Cortisol Analysis

- Wash hair with mild solvent (isopropanol) to remove external cortisol from sweat and sebum.
- Grind dried hair into a powder to increase surface area for extraction.
- Extract cortisol with methanol.
- Evaporate methanol and reconstitute in assay buffer.
- Analyze cortisol using sensitive and specific enzyme immunoassay (Salimetrics).

Applications of Hair Cortisol

- Chronic stress
- Psychopathology
- Drug abuse
- Development
- Wildlife conservation
- Archival samples

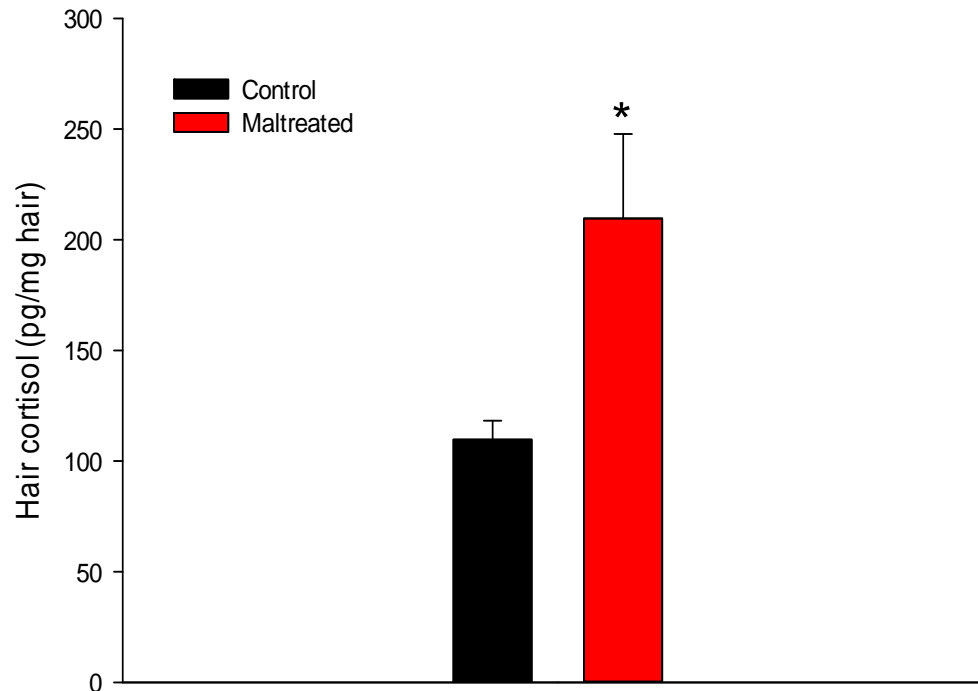
Hair Cortisol Concentrations in Rhesus Monkeys Subjected to Relocation Stress



Rhesus monkeys at the New England Primate Research Center were subjected to an administratively mandated relocation to a new building. Hair samples were collected pre-move and again 2 months and 1 year later. Davenport et al. (2006)

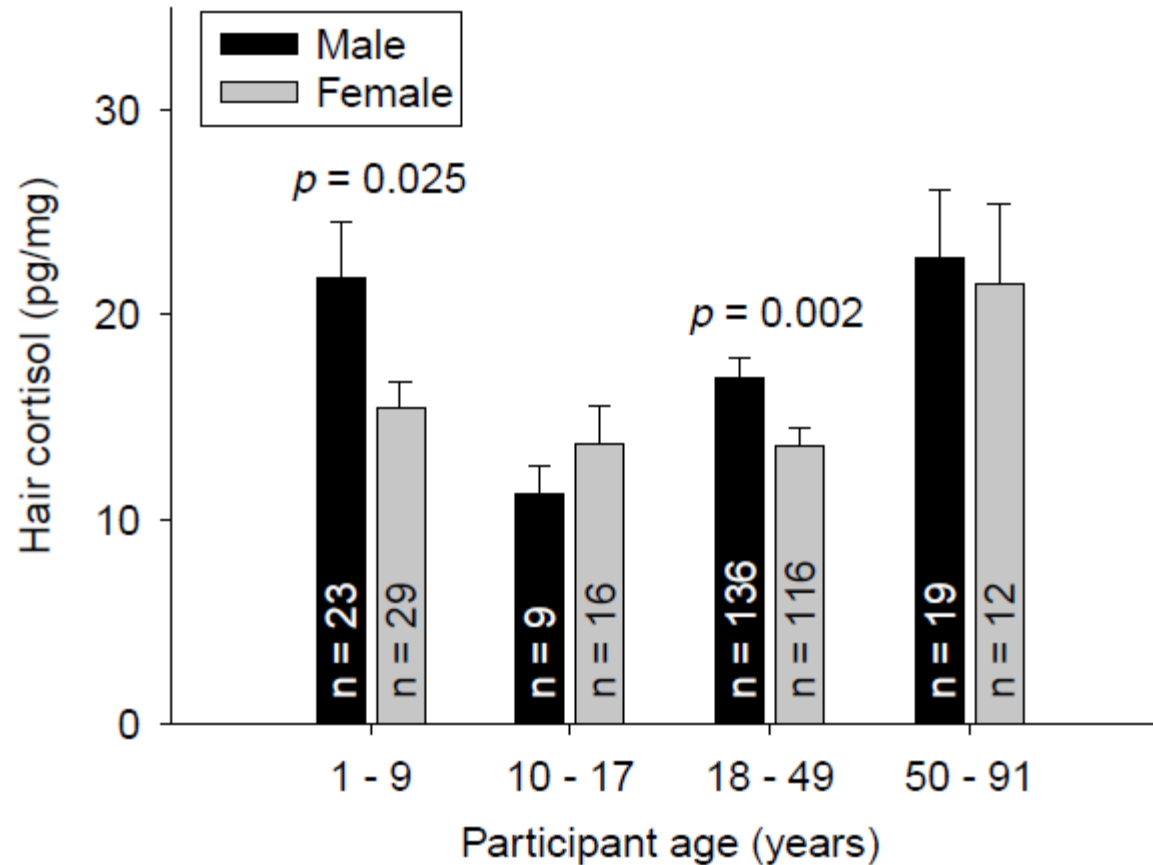
Hair Cortisol Concentrations in Infant Rhesus Monkeys Reared by Abusive vs. Nurturing Mothers

Cortisol accumulated in hair from birth through 6 months



Sanchez et al. (unpublished data)

Normative Developmental Changes in Hair Cortisol Levels



Hair Cortisol Concentrations in Shift Workers Compared to Day Workers

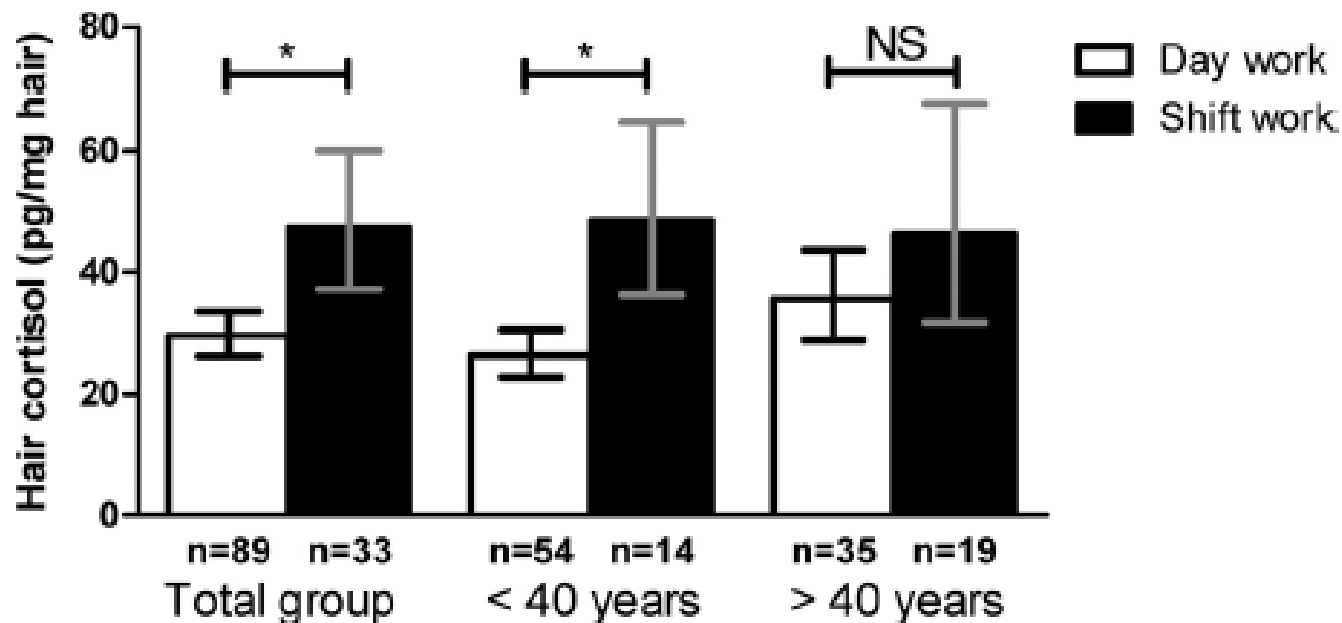
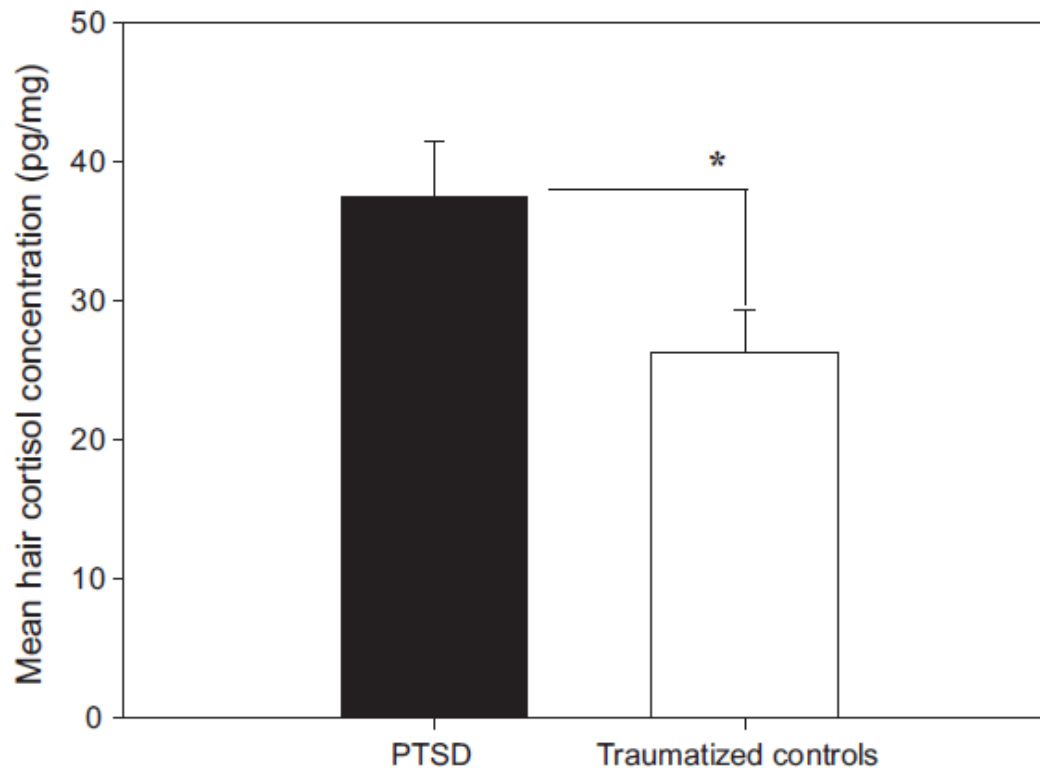


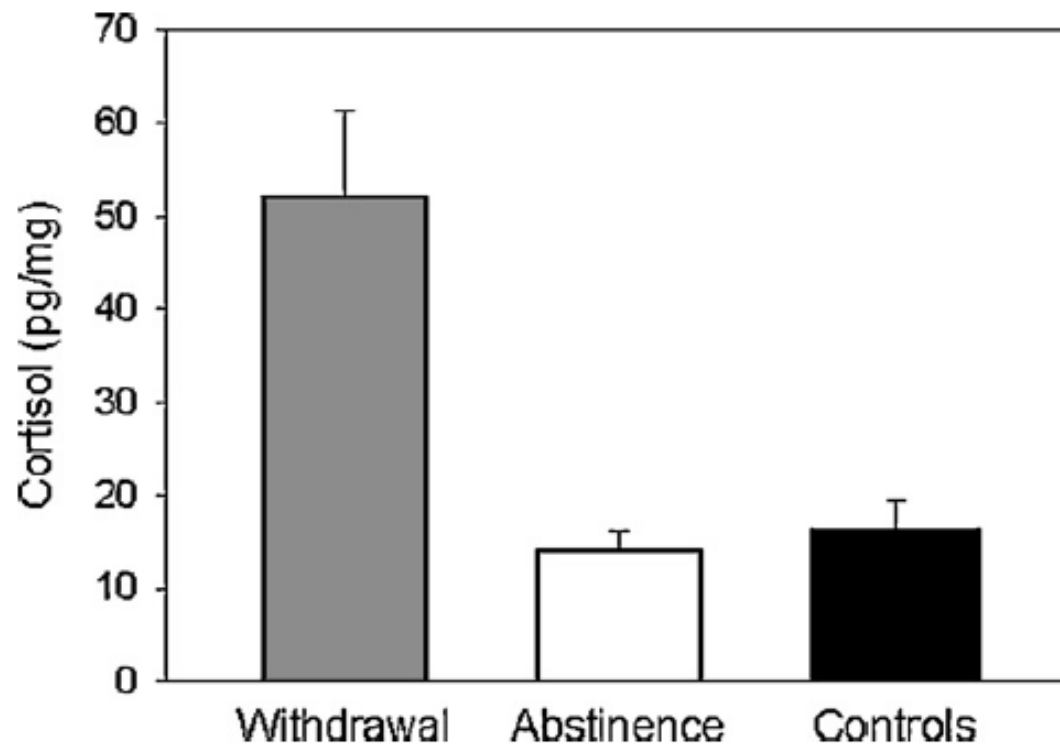
FIG. 1. Long-term cortisol levels in shift workers and day workers in total and divided into age groups, based on the median age of shift workers. *, $P < 0.001$ (unadjusted). NS, Not significant. Data are shown as geometric mean with 95% CI.

Hair Cortisol Concentrations in PTSD Patients



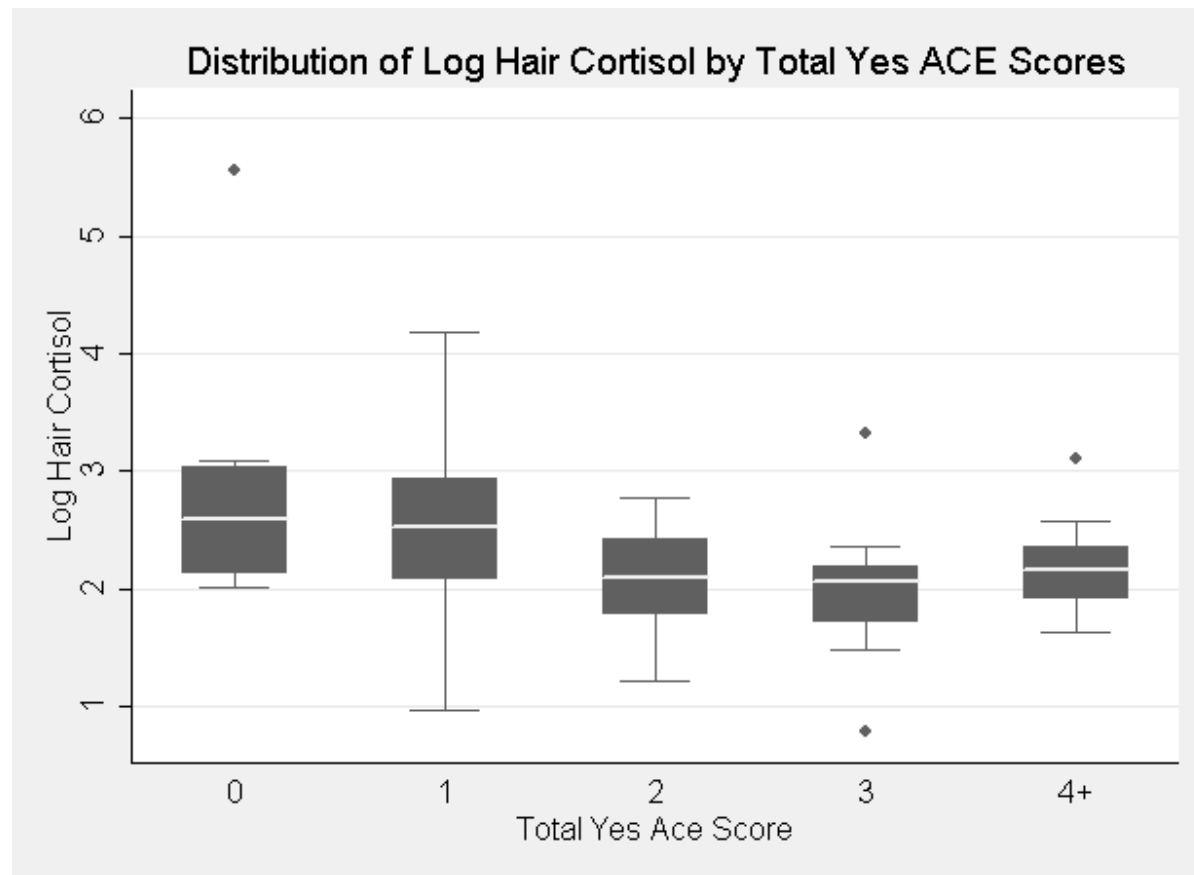
Participants were young Ugandan women who had been severely traumatized, some of whom subsequently developed PTSD. Hair cortisol was significantly elevated in the PTSD group compared to the traumatized controls. Steudte et al. (2011)

Hair Cortisol Concentrations in Alcoholics (abstinent vs. acute withdrawal)



Alcoholic subjects were either in acute withdrawal (2nd to 12th day) or had been abstinent for at least 14 weeks. Stalder et al. (2010)

Hair Cortisol and Adverse Childhood Experiences in College Students



Hair cortisol levels were significantly lower in college students who scored higher on the Adverse Childhood Experience questionnaire. Kalmakis et al. (in preparation)

Polar Bear Museum vs. Recent Samples



Bechshøft et al. (2012)

Summary

- Cortisol is slowly deposited into the growing hair shaft over periods of weeks to months.
- Hair cortisol can serve as an integrated measure of long-term hypothalamic-pituitary-adrenocortical activity, and thus chronic stress.
- Hair sampling is non-invasive
- Cortisol is highly stable in hair for years, even when maintained at ambient temperature.
- Other steroid hormones (e.g., progesterone, testosterone) are also deposited in hair.
- Limitations of hair cortisol include a lack of sensitivity to acute stressors or changes in circadian rhythmicity.

Resources

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References:

- (1) Meyer and Novak (2012) Minireview: Hair cortisol: A novel biomarker of hypothalamic-pituitary-adrenocortical activity. *Endocrinology* 153: 4120–4127.
- (2) Meyer et al. (2014) Extraction and analysis of cortisol from human and monkey hair. *Journal of Visualized Experiments* 83: e50882.