



Rocky Mountain Analytical®
Changing lives, one test at a time

Hair Cortisol

Clinical Information for Professionals

Hair Cortisol

Chronic Stress

During conditions of stress the hypothalamus and pituitary gland direct the adrenal glands to release cortisol, catecholamines, cytokines, and neuropeptides. Although chemical mediators of the stress response offer short-term benefits, they cause damage if they remain active when no longer needed. However, if the system is overworked and fails to shut down when stress abates, the physiologic effects of stress can accumulate. This accumulation is known as *high allostatic load*.¹

A high allostatic load is considered a risk factor for developing chronic illness. Clinical depression, flare-up of autoimmune disease, symptoms of upper respiratory infection following exposure to viruses and accelerated progression of chronic diseases like AIDS and heart disease have all been linked with chronic stress.² As more than 70% of disease is thought to be stress-related; identifying

and treating individuals with a high allostatic load could potentially reduce the burden of chronic disease. According to MacEwan, elevated or flattened diurnal cortisol rhythms and a low ratio of dehydroepiandrosterone (DHEAS) to cortisol are two primary indicators of a high allostatic load (along with inflammatory cytokines, elevated urinary cortisol and/or catecholamines).¹ Both urine steroid and saliva hormone testing are considered good biomarkers of *acute* stress, and may provide insight into allostatic load. However, acute stressors, even when severe, may elevate cortisol but not affect basal cortisol output. In contrast, prolonged or extremely severe stressors may lead to suppression of basal cortisol output. Russell et. al. suggest that hair cortisol may be a better biomarker for assessing *chronic* stress as it assesses cortisol over a longer term and is a tissue sample.³

Cardiovascular Disease

- Those with the highest levels of hair cortisol were significantly more likely to have had a diagnosis of cardiovascular disease, peripheral arterial disease and Type II diabetes, even after adjustment for other variables.^{4,5} Note that this does not necessarily mean that healthy individuals with elevated hair cortisol are automatically at higher risk for cardiovascular disease.
- Fifty-six men admitted to hospital for acute MI along with an equal number of non-MI admissions were assessed for hair cortisol levels. Combined data showed that as hair cortisol levels increased, the incidence of acute MI also increased. This suggests, for men at least, that elevated hair cortisol may predict future risk of heart disease.⁶
- High hair cortisol levels have also correlated with severity of congestive heart failure.⁷

Athletes

- The scalp hair of endurance athletes (e.g. triathletes, long distance runners, cyclists) is approximately 50% higher than that of less active controls.⁸ A drop in previously elevated hair cortisol may presage or reflect overtraining or decompensation. Note: cortisol levels in sweat increase after vigorous exercise, which may explain the elevated hair cortisol levels found in athletes.⁹

Mood Disorders

- **Bipolar Disorder:** Hair cortisol is positively correlated to a diagnosis of bipolar disorder, when onset of bipolar disorder occurs after age 30.¹⁰
- **Post Traumatic Stress Disorder (PTSD):** Studies suggest that survivors of trauma have lower hair cortisol levels post-trauma than non-traumatized controls.^{11,12}
- **Anxiety:** Hair cortisol levels in patients with Generalized Anxiety Disorder were on average, 50% lower than controls. It is unknown whether low hair cortisol is a consequence of, or contributing factor to, anxiety symptoms.¹³
- **Depression:** Depressed patients have been shown to have higher hair cortisol levels than controls.^{14,15} Normal hair cortisol levels may occur in depressed patients with a history of childhood trauma via the following mechanism: depression increases hair cortisol, while trauma history blunts it.

Chronic Pain

- Hair cortisol is significantly elevated in patients suffering from chronic pain compared to pain-free controls.¹⁶



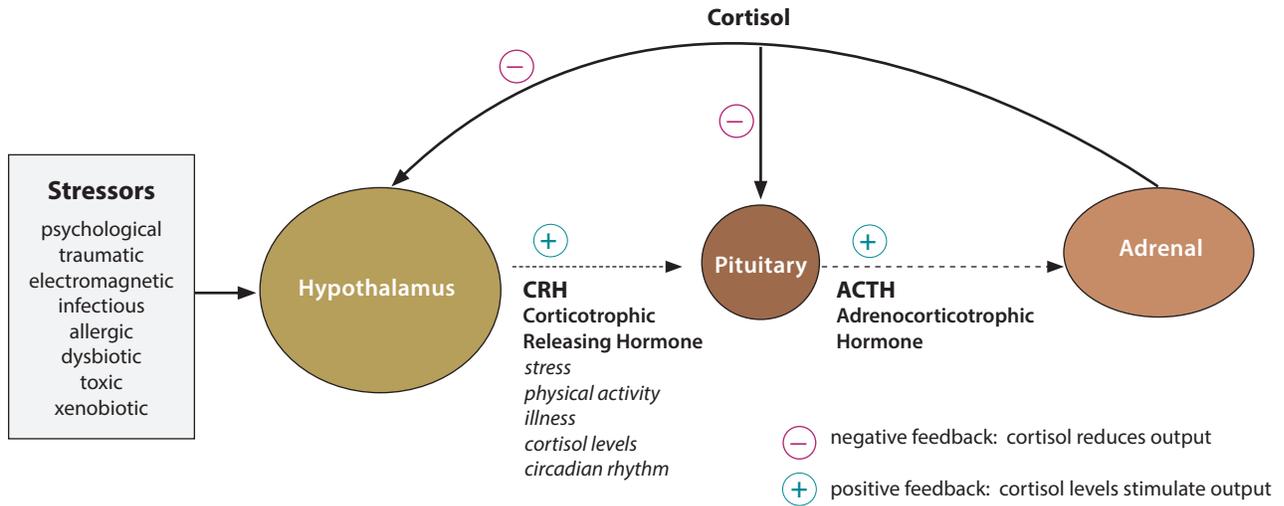
Cortisol

Hair Cortisol is a biomarker for chronic stress



Hypothalamic-Pituitary-Adrenal Axis

HPA Axis



Impact of Stress on the HPA Axis

Miller et al. completed a meta-analysis of studies on cortisol levels and stress in which they sought to determine whether different stressors affected the HPA axis differently. Their objective was to see which stressors increased HPA axis activity and which decreased it.² The preliminary findings are as follows:

- HPA activity increases with subjective distress
- HPA activity is decreased in those who develop PTSD after trauma
- cortisol output increases at onset of stressor, but diminishes over time
- HPA activity is increased when forms of stress are uncontrollable, traumatic in nature and pose a physical threat

Hair Cortisol & the HPA Axis

- Hair cortisol provides an independent, time-averaged cortisol level via a tissue (hair) that reflects the overall functioning of the hypothalamic-pituitary-adrenal (HPA) axis.
- Hair makes its own cortisol, but does so in communication with the central HPA axis, and therefore still reflects how the body responds to stress.

Comparing Hair, Urine and Saliva Testing for Cortisol

Urine and saliva typically assess HPA activity over a 24-hour period, whereas hair shows a 'time-averaged' assessment that reflects the overall functioning of the HPA axis over many weeks.

Hair: The first 1 cm of hair closest to the scalp represents approximately one month of cortisol production. Thus, hair cortisol is ideally suited for the assessment of long-term or chronic stress.

Saliva: Saliva is excellent for mapping out a diurnal rhythm. Graphing the cortisol level fluctuation through the day can inform on how well the hypothalamic pituitary axis functions. With chronic stress, the diurnal rhythm is often flattened, while acute stress is also typically observable in the diurnal pattern. A pooled cortisol sample from the month-long hormone assessment (11 samples) also provides a good view into adrenal function over a month.

Urine: Although a 24 hour urine collection obscures the diurnal rhythm, it provides valuable information regarding the total mass balance of cortisol produced (i.e. cortisol and cortisol metabolites).

Both saliva and urine are useful measures of acute response to stress, and may also provide evidence that chronic stress has suppressed cortisol output.

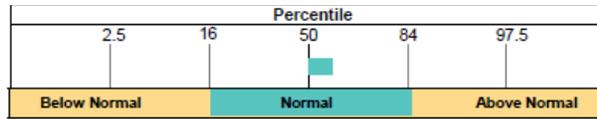
Range

NORMAL

5.9 - 22.6 pg/mg

Results Graph

Test	Status	Result	Range	Units
Hair cortisol	Normal	13.5	5.9 - 22	pg/mg



Normal Hair Cortisol Profile

- healthy, asymptomatic
- concomitant states: e.g. a depressed patient with post traumatic stress disorder. Depression elevates cortisol levels, but PTSD depresses the elevated levels to normal range.

Clinical Considerations

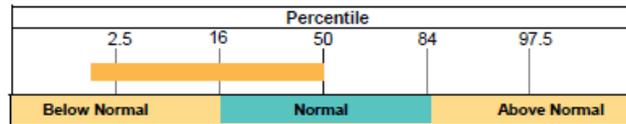
Normal hair cortisol levels in the absence of significant patient history or symptoms suggests normal HPA axis function.

A careful history is necessary to determine whether a normal level is consistent with patient history and symptoms.

LOW

< 5.9 pg/mg

Test	Status	Result	Range	Units
Hair cortisol	Below Normal	2.6	5.9 - 22	pg/mg



Low Hair Cortisol Profile

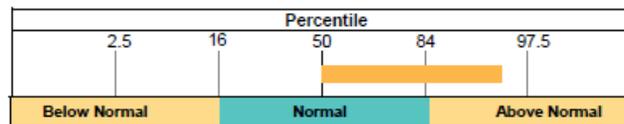
- cortisol levels decline with chronic stress.
- associated with generalized anxiety disorder.
- found in PTSD after a traumatic event.

Below normal hair cortisol indicates that cortisol levels are chronically depressed or blunted. Low cortisol may be a consequence of decreased cortisol output due to chronic stress, or to underlying physiology.

HIGH

> 22.6 pg/mg

Test	Status	Result	Range	Units
Hair cortisol	Above Normal	36.3	5.9 - 22	pg/mg



High Hair Cortisol Profile

- endurance athletes
- subjective distress
- high overall cortisol with stressors that are physically threatening, involve trauma and are out of individual's control
- if male, possibly at greater risk for cardiovascular issues.

Above normal hair cortisol indicates cortisol levels are chronically elevated. (1 month = 1 cm of hair). Chronically elevated cortisol may raise blood pressure and blood glucose plus contribute to disease progression.

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Reference Ranges

Reference ranges are based on a population of healthy Canadian subjects. This hair cortisol assay has been extensively validated with spike recovery experiments (more extensive than those previously published) and also by split sample testing via LCMSMS with deuterated internal standard. It has been reviewed and accredited by the College of Physicians and Surgeons of Alberta. Note that when hair sample provided is from the first 1/2 inch of fresh growth closest to the scalp, then the hair cortisol results reflects the average day-to-day cortisol output over the past month or so, since hair grows 1/2 inch or 1 centimeter per month.

Why Hair?

- Hair is a convenient sample as it is stable at room temperature for at least one year, and is easy to ship
- Hair cortisol levels correlate with salivary cortisol over time, and are therefore considered a valid measure.
- Measurement of analytes in hair, including drugs, is a very active area of research.
- The first 1 cm of hair closest to the scalp represents approximately one month of cortisol production.

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