LIFE Science Hub
JOURNAL OF SCIENCE
EXPANDING KNOWLEDGE ABOUT NUTRITION AND HEALTH

ORIGINAL RESEARCH
ISSN 2845-7501

# Association of hair glucocorticoid levels with sleep quality indicators: a pilot study in apparently healthy perimenopausal and menopausal women - Evidence review

**D.ssa D. Iodice**[1]

1 Biologist, Italy

## 1. ABSTRACT

The analyzed study evaluated whether subjective sleep quality was associated with hair cortisol and cortisone levels, which are indicators of long-term glucocorticoid exposure. It involved 145 apparently healthy women, aged between 50 and 64, in perimenopause or postmenopause. A worse sleep quality score was associated with higher hair cortisol concentrations; greater difficulty falling asleep was associated with higher levels of cortisol and total glucocorticoids.In "The Choice to Live in Health or Illness" by Dr. A. Colonnese and R. Panzironi, the publication contributes to the passage linking increased stress axis activity to poorer sleep quality. Independent studies confirm that sleep problems reported by individuals are associated with changes in cortisol, including that measured in hair. However, some research does not find the same relationship, and the observational design does not allow for the establishment of a causal direction.

ONLINE ARTICLE

ARTICLE INFORMATION

**Published:** November 20, 2026
**Updated:** November 20, 2026

**DOI** 10.5281/zenodo.24403567

MISSION

LIFE Science Hub – Journal of Science was founded with the aim of making scientific knowledge accessible without giving up methodological rigour, quality of sources and authoritativeness of content. The journal promotes the dissemination of knowledge in the health, nutrition, medical and longevity sciences, building a bridge between the world of research and society.

Through articles, reviews, in-depth analyses and expert contributions, the Journal champions evidence-based medicine and science, fostering a correct interpretation of scientific data and countering misinformation. Every piece of content is developed with the aim of translating the complexity of research into understandable, useful and applicable information, while keeping intact the principles of accuracy, transparency and scientific independence.

Free from political, industrial and commercial influence, the journal stands as an authoritative and independent editorial space, dedicated to promoting scientific culture, professional development and the growth of health awareness among the public.

## 2. ANALYZED STUDY

The research question was whether, in women between perimenopause and postmenopause, a perceived poorer sleep quality was associated with greater prolonged exposure to glucocorticoids. Glucocorticoids are hormones produced primarily by the adrenal glands; cortisol is the main one and participates in the body's stress response. The authors used cortisol and cortisone in hair as indicators of average exposure over the previous months, rather than a momentary variation detected in blood or saliva.The relevance to paragraph 4.15 of "The Choice to Live in Health or Illness" by Dr. A. Colonnese and R. Panzironi is specific: the research documents the segment of the narrative according to which greater activity of the hypothalamic-pituitary-adrenal axis, i.e., the neuroendocrine system that coordinates the stress response, is associated with less efficient sleep that is more difficult to initiate. It does not directly evaluate insulin sensitivity, insulin resistance, or the metabolic outcomes described in other parts of the paragraph.Since this is a cross-sectional study, which observes exposure and sleep quality during the same period, it can identify associations but cannot prove that increased glucocorticoids cause insomnia or that altered sleep increases glucocorticoids first. A bidirectional relationship or the influence of unmeasured factors is also plausible.

## 3. MATERIALS AND METHODS OF THE ORIGINAL STUDY

The study was a cross-sectional pilot study, meaning an exploratory investigation conducted during a single observation period. 145 apparently healthy women between 50 and 64 years of age, participating in a national cardiovascular prevention program in Lithuania, were recruited consecutively. Data collection took place between September 2020 and May 2021. The preliminary sample size calculation indicated 145 participants for an expected statistical power of 80%; however, a subsequent analysis estimated a power of 70% for the actual sample studied.Women with acute or chronic diseases were excluded, including cardiovascular conditions, diabetes, and chronic kidney disease, as well as mental disorders or the use of synthetic steroid hormones in the previous three months. None of the participants were using estrogen therapy. The median age was 55 years; 81.38% reported being in menopause and 17.93% in perimenopause.The cortisol and cortisone content was measured from the three-centimeter segment closest to the scalp using ultra-high-performance liquid chromatography coupled with tandem mass spectrometry, a laboratory technique that identifies and quantifies specific molecules. Considering an average hair growth of approximately one centimeter per month, the analyzed segment reflects approximately the previous three months. Hair washing frequency was not found to be statistically significantly associated with the measured hormone concentrations.Sleep was assessed using the Pittsburgh Sleep Quality Index, or PSQI, a questionnaire referring to the last month: higher scores, on a scale from 0 to 21, indicate worse quality; a score of 5 or higher is conventionally compatible with poor sleep. Perceived stress and trait anxiety were also evaluated through questionnaires. The analyses included group comparisons using non-parametric tests, Spearman correlations, and chi-square tests. Follow-up was not planned, as the design was cross-sectional.

## 4. RESULTS

In practical terms, women who reported greater difficulty falling asleep showed higher levels of prolonged cortisol exposure. The median hair cortisol level was 4.98 ng/g in the group with impaired sleep onset latency, compared to 3.04 ng/g in the group without such impairment; the difference was statistically significant, with P=0.018. Sleep onset latency is the time elapsed from the attempt to sleep until actual sleep occurs.The sum of cortisol and cortisone, defined as total glucocorticoids, was also higher in the group with impaired latency: 12.39 ng/g versus 9.86 ng/g, with P=0.017. Cortisone alone was numerically higher, 7.29 ng/g versus 5.90 ng/g, but this difference did not reach the conventional threshold of statistical significance in the comparison of medians, with P=0.086.Overall sleep quality did not show a statistically significant difference between the group with a PSQI lower than 5 and the group with a PSQI equal to or greater than 5 in the direct comparison of medians. However, considering the PSQI as a continuous score, hair cortisol increased slightly as the score worsened: Spearman's correlation coefficient

rs=0.179; P=0.032. Total glucocorticoids also increased slightly with a worse PSQI, rs=0.167; P=0.045, and with greater sleep disturbances, rs=0.169; P=0.043.The magnitude of the correlations was weak. This means that the observed relationship existed at the group level, but the hair cortisol value alone was not sufficient to accurately predict how an individual person slept. By dividing the sample around the median cortisol level, a concentration lower than 3.58 ng/g was associated with better sleep efficiency, that is, a higher percentage of time spent in bed actually spent sleeping: P=0.044. The results related to the other components of the questionnaire were not statistically significant.

## 5. INTERPRETATION

The main significance is that, in this group of middle-aged women, sleep perceived as more problematic tended to coexist with greater prolonged exposure to glucocorticoids. The most consistent result concerned falling asleep: those who took longer to fall asleep had higher concentrations of cortisol and total glucocorticoids in their hair.From a biological perspective, this finding is compatible with increased activation of the hypothalamic-pituitary-adrenal axis. Under normal conditions, this system helps organize the daily rhythm of cortisol. If its functioning remains more active or less well-synchronized, it can be accompanied by an increase in physiological arousal in the evening, making it more difficult to initiate or maintain sleep. However, the study did not directly measure axis activity in real-time, nor did it evaluate evening or nighttime cortisol in the blood or saliva.In the passage from "The Choice to Live in Health or Illness" by Dr. A. Colonnese and R. Panzironi, the publication therefore supports the specific link: greater long-term exposure to glucocorticoids worse subjective sleep quality, in particular longer sleep latency and lower efficiency. It does not, however, demonstrate that elevated cortisol precedes sleep disturbance, nor that this association directly causes insulin resistance or other metabolic alterations.The main limitations are the small sample size, the selected sample of apparently healthy and predominantly postmenopausal women, the subjective assessment of sleep, and the absence of objective measures such as actigraphy or polysomnography. Furthermore, there are no universally accepted reference values for cortisol and cortisone in hair; this limits the use of the data as an individual test.

## 6. INDEPENDENT SUPPORTING EVIDENCE

Confirmation that closely aligns with the narrative of this paragraph comes from a Canadian cross-sectional study of 483 adults, including 306 women. After adjusting for variables that can influence stress and sleep, poor subjective sleep quality, defined by a PSQI score greater than 5, was associated with higher hair cortisol concentrations, with P=0.020; a higher mean PSQI score was also associated with higher cortisol, with P=0.027. This evidence directly confirms the link between poorer reported sleep and higher hair cortisol, but it does not define the direction of causality and is not limited to menopausal women [1].A second cross-sectional study, conducted in China on 435 workers, reinforces the biological consistency of the relationship in a context of rhythm disruption. Compared to stable daytime work, various shift work schedules were associated with both a higher prevalence of sleep disorders and higher mean hair cortisol concentrations. Furthermore, elevated hair cortisol levels were associated with a higher prevalence of sleep disorders, with an odds ratio, or OR, of 4.46 and a 95% confidence interval from 2.70 to 7.35. The OR compares the odds of the outcome between groups: in this case, the association was in the direction of more sleep disorders among those with higher hair cortisol. However, the work context, the use of questionnaires, and the cross-sectional design prevent causal conclusions [2].A longitudinal study from the Whitehall II cohort documented a complementary segment of the chain: recurring sleep problems preceded alterations in the daily rhythm of salivary cortisol. In 3,314 adults, recurring short sleep, defined as five hours or less, was associated with a flatter cortisol curve throughout the day. Those who reported short sleep in all three assessments had higher concentrations in the hours following awakening compared to those who never reported short sleep; the interaction with hours since awakening was b=0.02, with a 95% confidence interval from 0.01 to 0.03. This study does not measure hair cortisol, but it confirms that repeated sleep disturbance is associated over time with a less favorable cortisol rhythm [3].

## 7. CONFLICTING EVIDENCE

Not all research observes a relationship between self-reported sleep quality and hair cortisol. In a study of healthcare workers during the first wave of the COVID-19 pandemic, 67 nurses provided hair samples that were analyzed in two time segments. Hair cortisol was higher during the pandemic period and in workers exposed to greater occupational risk, but none of the subjective questionnaires, including the PSQI, significantly predicted hair cortisol [4].This evidence does not invalidate the scientific correspondence of the publication subject to the Evidence Review. However, it indicates that the relationship may depend on the context, the population studied, the intensity of the stress, the duration examined, and the fact that the questionnaire and the biomarker represent different time windows. Even in the Canadian confirmation study, hair cortisol was associated with the PSQI but not with objective measures obtained via actigraphy, a tool that estimates movement and sleep using a wearable sensor [1].Overall, the conflicting evidence suggests caution: hair cortisol is a useful indicator for population studies on prolonged stress exposure, but it cannot be interpreted as standalone proof of insomnia or as a diagnostic measure of individual sleep quality.

## 8. QUADRO COMPARATIVO E SINTESI DELLE EVIDENZE

The table distinguishes the publication subject to the review from independent research and shows the level at which each contributes to the narrative.

### Quadro comparativo

| Reference | Study type | Population or model | Main result | Direction of evidence | Strength of evidence |
|---|---|---|---|---|---|
| Original study | Pilot cross-sectional | 145 apparently healthy women, 50-64 years old, in peri- or postmenopause | Higher hair cortisol and total glucocorticoids associated with longer sleep onset latency; weak correlations with worse PSQI | direct confirmation | moderate |
| [1] | Cross-sectional observational | 483 Canadian adults, 306 women | PSQI greater than 5 and higher mean PSQI score associated with higher hair cortisol; no association with actigraphy | direct confirmation | moderate |
| [2] | Cross-sectional observational | 435 Chinese workers, men and women | Shift work associated with more sleep disturbances and higher hair cortisol; high cortisol associated with higher prevalence of disorders | indirect confirmation | moderate |

| | | | | | |
|---|---|---|---|---|---|
| [3] | Longitudinal observational | 3,314 adults from the Whitehall II cohort | Recurrent short sleep associated with a flatter salivary cortisol curve and higher cortisol in the late hours of the day | biologically consistent evidence | moderate |
| [4] | Observational with temporal comparison | 67 nurses with hair samples during the COVID-19 pandemic | Hair cortisol increased during the pandemic, but PSQI was not predictive of cortisol levels | discordant evidence | low |

## 9. SINTESI EDITORIALE E CONCLUSIONI

### CONCLUSIONS

The study analyzed supports an association between greater prolonged exposure to glucocorticoids and poorer subjective sleep quality in peri- and postmenopausal women. The clearest signal concerns greater difficulty falling asleep and lower sleep efficiency. This narrative is moderately supported by independent evidence, including observations in larger populations and longitudinal data on the circadian rhythm of cortisol.However, it remains necessary to distinguish between association and causality. It is not possible to conclude that increased cortisol causes sleep disturbances, nor that sleep disturbances necessarily increase cortisol first. Longitudinal and experimental studies, with objective sleep measurements and representative samples of menopausal women, are needed to clarify the direction, mechanisms, and clinical relevance of this relationship.

Aggiornato al 24/11/2026. Questo contenuto riflette una sintesi divulgativa delle evidenze scientifiche al momento della pubblicazione e non sostituisce il parere medico.

## 10. TRANSPARENCY AND SCIENTIFIC RESPONSIBILITY

Artificial Intelligence was used solely as a tool for editorial and documentary support. All content, interpretations, bibliographic citations and conclusions have been verified, reviewed and approved by the author, who assumes full scientific responsibility for them.

The manuscript was also subjected to independent peer review prior to publication.

To ensure the greatest transparency, the complete history of the article, including the dates of submission, revision, acceptance and publication, as well as information on the peer review process, is available on the dedicated Article History page.

## 11. RIFERIMENTI BIBLIOGRAFICI

[1] **Elevated Hair Cortisol Concentrations Are Associated With Poor Sleep Quality Evaluated Using the Pittsburgh Sleep Quality Index but Not With Actigraphy**
Michaud et al., 2026
*Journal of Sleep Research*
DOI: https://doi.org/10.1111/jsr.70105

[2] **Relationships among shift work, hair cortisol concentration and sleep disorders: a cross-sectional study in China**
Zhang et al., 2020
*BMJ Open*
DOI: https://doi.org/10.1136/bmjopen-2020-038786

[3] **Recurrent short sleep, chronic insomnia symptoms and salivary cortisol: A 10-year follow-up in the Whitehall II study**
Abell et al., 2016
*Psychoneuroendocrinology*
DOI: https://doi.org/10.1016/j.psyneuen.2016.02.021

[4] **Stress and hair cortisol concentrations in nurses during the first wave of the COVID-19 pandemic**
Rajcani et al., 2021
*Psychoneuroendocrinology*
DOI: https://doi.org/10.1016/j.psyneuen.2021.105245