

## Factors That May Affect the Cortisol Awakening Response (CAR)

- Age<sup>1,2,3</sup>
  - Research suggests young children exhibit a distinct yet smaller CAR than adults. Research also shows the CAR amplitude decreases with aging in adults over 55.
- Alcohol Consumption<sup>4</sup>
  - Research suggests alcohol consumption may contribute to an attenuated CAR.
- Anticipated Daily Stress, Activities, and Workload (Workday vs. Day Off)<sup>5,6,7,8,9</sup>
  - Higher anticipatory stress, workload, and daily activities are associated with a more robust CAR.
- Chronotype<sup>10,11</sup>
  - Research suggests morning chronotypes might show higher cortisol awakening response levels than evening chronotypes.
- Early Life Stress (ELS)<sup>12,13,14,15,16</sup>
  - Research is still clarifying the association, but some research suggests higher ELS in early puberty is associated with a blunted CAR. In comparison, higher ELS in later puberty is associated with a heightened CAR. Other research indicates that healthy males who experience ELS in childhood, as opposed to adolescence, cumulative ELS, and or physical abuse, are at risk of having an elevated CAR. Additional research suggests no significant association between ELS and cortisol levels, while others suggest the effects of ELS on the CAR could be mediated by genetic factors.
- Exercise<sup>17,18</sup>
  - Research suggests the CAR is significantly lower after evening exercise. More research is needed to fully elucidate the influence of exercise on the CAR and clarify gaps in the literature.
- Exposure to Artificial Light at Night<sup>19,20</sup>
  - Research suggests that exposure to artificial light and reading on a smartphone without a blue light filter (BLF) at night significantly decreases the CAR in the morning.
- Exposure to Cell Phone/EMF<sup>19,20,21</sup>
  - Research suggests that nighttime reading on a smartphone without a blue light filter (BLF) significantly decreases the CAR in the morning compared to reading on a smartphone with a BLF and reading printed material. More research is needed to clarify the potential effects of EMF on the CAR.
- Exposure to Secondhand Smoke<sup>22</sup>
  - Research suggests infants of mothers who smoked during pregnancy have a higher CAR amplitude than infants of mothers who did not smoke during pregnancy. More research is needed.
- Family Conflict<sup>23</sup>
  - Research suggests adults with high family conflict have lower morning cortisol levels at 30, 60, and 90 min after awakening than those with low family conflict. Thus, family conflict could contribute to an attenuated CAR, though more research is needed.
- Gut Microbiome<sup>24,25,26</sup>
  - Research shows the relative abundance of some bacterial genera may correlate positively with the amplitude of the CAR. A multivariate analysis of the results of one clinical trial suggests six weeks of supplementation with *Bifidobacterium longum* led to a reduction in perceived stress, anxiety, depression, and CAR amplitudes in healthy adults with mild-to-moderate stress. A different clinical trial determined that eight weeks of supplementation with a combination of *Bifidobacterium longum* strains 1714® and 35642® attenuated stress responses and restored blunted CARs in those with IBS. More research is needed.
- Meal Times<sup>27</sup>
  - Research suggests eating the mid-day meal late in the afternoon contributes to a blunted daily cortisol profile with lower morning and afternoon cortisol levels than eating this meal at midday.

- Medications, including Corticosteroids, Opiates, Retinoids, and Aspirin<sup>28,29,30,31,32,33</sup>
  - The use of corticosteroids, aspirin, opiates, and retinoids, such as bexarotene, alitretinoin, and isotretinoin, can contribute to adrenal insufficiency and, therefore, a blunted CAR.
- Menstrual Cycle<sup>34,35</sup>
  - Research suggests the CAR could be more robust when estradiol levels are higher during ovulation and the luteal phase, though the results of some studies conflict with these findings. More research is needed.
- Napping<sup>36</sup>
  - Research suggests longer prior-day naps are associated with a higher CAR.
- Pain Threshold<sup>37</sup>
  - Research suggests pressure pain threshold (PPT) positively correlates with the CAR. Those with a relatively blunted CAR have a significantly lower PPT than those with a relatively normal CAR.
- Perceived Lack of Control<sup>7</sup>
  - One clinical study suggests self-reported moderate or low control is reported more often on work days than weekend days. Therefore, lower perceived control could be associated with a more robust CAR. More research is needed.
- Perceived Readiness<sup>38</sup>
  - Research suggests lower perceived readiness is associated with a reduced CAR and worse cognitive performance.
- Perceived Stress Management Skills<sup>39</sup>
  - Research reveals that greater Perceived Stress Management Skills (PSMS) are associated with a greater CAR amplitude.
- Postpartum Status<sup>40</sup>
  - Research reveals a unique hormonal landscape during the postpartum period including a blunted CAR in healthy women early postpartum when compared to non-perinatal healthy women.
- Pubertal Status<sup>23</sup>
  - Research suggests a significant interaction between pubertal status and the cortisol awakening response in adolescents with healthy family dynamics. Those at late/post-pubertal status had higher CAR levels than those at pre/early-pubertal status. The significant interaction could also be due to age. More research is needed.
- Reported Level of Happiness<sup>41</sup>
  - Research suggests high happiness is associated with a flexible CAR (i.e., lower CAR during weekends compared to workdays), whereas low happiness is associated with a more rigid CAR. The impact of happiness on the CAR magnitude is less clear. More research is needed.
- Resilience<sup>42</sup>
  - Research shows higher self-reported resilience is associated with a larger CAR magnitude.
- Sex (Biological)<sup>37,43,44,45,46,47</sup>
  - Some studies report sex differences in the CAR. Research shows females display a greater increase in cortisol levels between awakening and 30 minutes post-awakening than males during work days. Other studies have failed to observe any differences in the CAR between healthy males and females, but differences have been detected in unhealthy populations. Research suggests elevated cortisol awakening responses are present in female, but not male, patients with borderline personality disorder compared to healthy volunteers. Research also shows men with knee osteoarthritis have a significantly higher CAR than women with the same condition. In individuals with metabolic syndrome, women produce a greater relative CAR than men. Women with chronic fatigue syndrome (CFS) exhibit a significantly attenuated morning cortisol profile compared with healthy women. However, cortisol profiles are similar in healthy males and males with CFS. One clinical study that included adolescents with recurrent pain suggests sex is a significant predictor

of cortisol levels, with girls exhibiting a more robust CAR than boys. Research also suggests a blunted CAR is associated with obsessing symptoms in women with obsessive-compulsive disorder, but not men.

- **Sleep Duration**<sup>1,48,49,50</sup>
  - Two clinical studies suggest sleep duration significantly affects the CAR in young children. One study provided strong evidence that shortening sleep duration in a young child by about two hours significantly reduces overall cortisol secretion during the 45-minute post-awakening period. Another clinical study that included adult men assessed the CAR after napping and determined the magnitude of the CAR after a nap and nighttime sleep is dependent upon sleep duration. Specifically, morning and afternoon 90-minute naps consistently resulted in a CAR, while shorter 50-minute naps did not produce a CAR. Other studies found no association between sleep duration and the CAR, but these studies included self-reported sleep duration, whereas studies that show an association used polysomnography-verified sleep duration. More research is needed.
- **Sleep Architecture**<sup>49</sup>
  - Research suggests more time spent sleeping in Stage 2 overnight is associated with a larger CAR amplitude in the morning. The more time spent sleeping in Stage 1 overnight, the higher the cortisol level upon waking. More Stage 1 sleep during a 90-minute morning (but not afternoon) nap is associated with a greater CAR amplitude.
- **Socioeconomic Status**<sup>7,22,51</sup>
  - Overall, the evidence for an association between the amplitude of the CAR and socioeconomic status (SES) has been inconsistent. Some studies suggest that lower SES is associated with higher and lower total cortisol output. Null associations have also been reported. One clinical study of an adult population suggests lower SES is associated with a larger cortisol awakening response. Research suggests infants of low-income families have higher cortisol levels during the day and a higher CAR amplitude than infants of high-income families. A clinical study of adolescents discovered a curvilinear relationship between childhood income and the CAR. The results suggest that low childhood income is associated with the lowest and highest CAR amplitudes, potentially contributing to the inconsistent evidence. More research is needed.
- **Timing of Adoption**<sup>52</sup>
  - Research suggests that late-adopted children have a blunted CAR relative to non-adopted and earlier-adopted children.
- **Timing of Saliva Collection**<sup>53,54,55</sup>
  - Research suggests that delays in saliva collection can contribute to incorrect CAR calculations. The latest research emphasizes the importance of collecting within a few minutes of awakening. Collection delays of 7-15 minutes can underestimate the CAR. The evidence emphasizes the need for sampling accuracy when measuring the CAR for clinical and research purposes.
- **Work Schedule**<sup>56,57,58,59</sup>
  - Research suggests that night-shift nurses have blunted CARs and significantly lower cortisol levels 30 minutes after waking than day-shift and evening-shift nurses. A scoping review published in 2022 determined that shiftwork, especially the night shift, significantly disrupts the production of cortisol and the CAR. Researchers also discovered irregular shift schedules produce greater disruptions to cortisol production than regular shift schedules. While it is difficult to conclude the extent to which short-term vs. long-term shiftwork impacts the cortisol rhythm, the latest research confirms cortisol levels, the cortisol rhythm, and the CAR are disrupted by shiftwork. More research is needed.

- <sup>1</sup> Gribbin CE, Watamura SE, Cairns A, et al. [The cortisol awakening response \(CAR\) in 2- to 4-year-old children: effects of acute nighttime sleep restriction, wake time, and daytime napping](#). *Dev Psychobiol.* 2012;54(4):412-422. doi:10.1002/dev.20599
- <sup>2</sup> Bernsdorf M, Schwabe L. [Cortisol response to awakening in prepubertal children and adults: Magnitude and variability](#). *Psychophysiology.* 2018;55(12):e13273. doi:10.1111/psyp.13273
- <sup>3</sup> Wang X, Sánchez BN, Golden SH, et al. [Stability and predictors of change in salivary cortisol measures over six years: MESA](#). *Psychoneuroendocrinology.* 2014;49:310-320. doi:10.1016/j.psyneuen.2014.07.024
- <sup>4</sup> Ceballos N, Perrotte J, Sharma S, et al. [Women who pre-game: A study of stress and alcohol use in female collegiate predrinkers](#). *J Am Coll Health.* Published online August 15, 2023. doi:10.1080/07448481.2023.2245499
- <sup>5</sup> Elder GJ, Ellis JG, Barclay NL, Wetherell MA. [Assessing the daily stability of the cortisol awakening response in a controlled environment](#). *BMC Psychol.* 2016;4:3. doi:10.1186/s40359-016-0107-6
- <sup>6</sup> Kramer AC, Neubauer AB, Stoffel M, et al. [Tomorrow's gonna suck: Today's stress anticipation predicts tomorrow's post-awakening cortisol increase](#). *Psychoneuroendocrinology.* 2019;106:38-46. doi:10.1016/j.psyneuen.2019.03.024
- <sup>7</sup> Kunz-Ebrecht SR, Kirschbaum C, Marmot M, Steptoe A. [Differences in cortisol awakening response on work days and weekends in women and men from the Whitehall II cohort](#). *Psychoneuroendocrinology.* 2004;29(4):516-528. doi:10.1016/s0306-4530(03)00072-6
- <sup>8</sup> Braun D, Frank M, Theiler L, Petrowski K. [Cortisol awakening response in the airborne rescue service](#). *Occup Med (Lond).* 2022;72(5):332-338. doi:10.1093/occmed/kqac052
- <sup>9</sup> Hibel LC, Trumbell JM, Mercado E. [Work/non-workday differences in mother, child, and mother-child morning cortisol in a sample of working mothers and their children](#). *Early Hum Dev.* 2014;90(1):1-7. doi:10.1016/j.earlhumdev.2013.11.007
- <sup>10</sup> Kudielka BM, Federenko IS, Hellhammer DH, Wüst S. [Morningness and eveningness: the free cortisol rise after awakening in "early birds" and "night owls"](#). *Biol Psychol.* 2006;72(2):141-146. doi:10.1016/j.biopsycho.2005.08.003
- <sup>11</sup> Facer-Childs ER, Middleton B, Bagshaw AP, Skene DJ. [Human Circadian Phenotyping and Diurnal Performance Testing in the Real World](#). *J Vis Exp.* 2020;(158):10.3791/60448. doi:10.3791/60448
- <sup>12</sup> King LS, Colich NL, LeMoult J, et al. [The impact of the severity of early life stress on diurnal cortisol: The role of puberty](#). *Psychoneuroendocrinology.* 2017;77:68-74. doi:10.1016/j.psyneuen.2016.11.024
- <sup>13</sup> Butler K, Klaus K, Edwards L, Pennington K. [Elevated cortisol awakening response associated with early life stress and impaired executive function in healthy adult males](#). *Horm Behav.* 2017;95:13-21. doi:10.1016/j.yhbeh.2017.07.013
- <sup>14</sup> Fogelman N, Canli T. [Early life stress and cortisol: A meta-analysis](#). *Horm Behav.* 2018;98:63-76. doi:10.1016/j.yhbeh.2017.12.014
- <sup>15</sup> Klaus K, Butler K, Gutierrez H, et al. [Interactive effects of early life stress and CACNA1C genotype on cortisol awakening response](#). *Biol Psychol.* 2018;136:22-28. doi:10.1016/j.biopsycho.2018.05.002
- <sup>16</sup> Ortiz R, Zhao S, Kline DM, et al. [Childhood environment early life stress, caregiver warmth, and associations with the cortisol diurnal curve in adulthood: The coronary artery risk development in young adults \(CARDIA\) study](#). *Psychoneuroendocrinology.* 2023;149:106008. doi:10.1016/j.psyneuen.2022.106008
- <sup>17</sup> Anderson T, Vrshek-Schallhorn S, Adams WM, et al. [The effect of acute exercise on the cortisol awakening response](#). *Eur J Appl Physiol.* 2023;123(5):1027-1039. doi:10.1007/s00421-023-05132-4
- <sup>18</sup> Anderson T, Wideman L. [Exercise and the Cortisol Awakening Response: A Systematic Review](#). *Sports Med Open.* 2017;3(1):37. doi:10.1186/s40798-017-0102-3

- 
- <sup>19</sup> Höhn C, Schmid SR, Plamberger CP, et al. [Preliminary Results: The Impact of Smartphone Use and Short-Wavelength Light during the Evening on Circadian Rhythm, Sleep and Alertness](#). *Clocks Sleep*. 2021;3(1):66-86. doi:10.3390/clockssleep3010005
- <sup>20</sup> Schmid SR, Höhn C, Bothe K, et al. [How Smart Is It to Go to Bed with the Phone? The Impact of Short-Wavelength Light and Affective States on Sleep and Circadian Rhythms](#). *Clocks Sleep*. 2021;3(4):558-580. doi:10.3390/clockssleep3040040
- <sup>21</sup> Selmaoui B, Touitou Y. [Association Between Mobile Phone Radiation Exposure and the Secretion of Melatonin and Cortisol, Two Markers of the Circadian System: A Review](#). *Bioelectromagnetics*. 2021;42(1):5-17. doi:10.1002/bem.22310
- <sup>22</sup> Saridjan NS, Huizink AC, Koetsier JA, et al. [Do social disadvantage and early family adversity affect the diurnal cortisol rhythm in infants? The Generation R Study](#). *Horm Behav*. 2010;57(2):247-254. doi:10.1016/j.yhbeh.2009.12.001
- <sup>23</sup> Zhang J, Lam SP, Kong AP, et al. [Family conflict and lower morning cortisol in adolescents and adults: modulation of puberty](#). *Sci Rep*. 2016;6:22531. doi:10.1038/srep22531
- <sup>24</sup> Caputi V, Bastiaanssen TFS, Peterson V, et al. [Sex, pain, and the microbiome: The relationship between baseline gut microbiota composition, gender and somatic pain in healthy individuals](#). *Brain Behav Immun*. 2022;104:191-204. doi:10.1016/j.bbi.2022.06.002
- <sup>25</sup> Boehme M, Rémond-Derbez N, Lerond C, et al. [Bifidobacterium longum subsp. longum Reduces Perceived Psychological Stress in Healthy Adults: An Exploratory Clinical Trial](#). *Nutrients*. 2023;15(14):3122. doi:10.3390/nu15143122
- <sup>26</sup> Groeger D, Murphy EF, Tan HTT, et al. [Interactions between symptoms and psychological status in irritable bowel syndrome: An exploratory study of the impact of a probiotic combination](#). *Neurogastroenterol Motil*. 2023;35(1):e14477. doi:10.1111/nmo.14477
- <sup>27</sup> Bandín C, Scheer FA, Luque AJ, et al. [Meal timing affects glucose tolerance, substrate oxidation and circadian-related variables: A randomized, crossover trial](#). *Int J Obes (Lond)*. 2015;39(5):828-833. doi:10.1038/ijo.2014.182
- <sup>28</sup> Watson S, Horton K, Bulmer S, et al. [Effect of aspirin on hypothalamic-pituitary-adrenal function and on neuropsychological performance in healthy adults: a pilot study](#). *Psychopharmacology (Berl)*. 2009;205(1):151-155. doi:10.1007/s00213-009-1525-4
- <sup>29</sup> Kachroo P, Stewart ID, Kelly RS, et al. [Metabolomic profiling reveals extensive adrenal suppression due to inhaled corticosteroid therapy in asthma](#) [published correction appears in *Nat Med*. 2022 Aug;28(8):1723. doi:10.1038/s41591-022-01949-2]. *Nat Med*. 2022;28(4):814-822. doi:10.1038/s41591-022-01714-5
- <sup>30</sup> Borresen SW, Klose M, Glinborg D, et al. [Approach to the Patient With Glucocorticoid-induced Adrenal Insufficiency](#). *J Clin Endocrinol Metab*. 2022;107(7):2065-2076. doi:10.1210/clinem/dgac151
- <sup>31</sup> Mohamed Khair A. [Long-Term Opiate Therapy-Induced Secondary Adrenal Insufficiency: A Distinct Differential Diagnosis That Should Be Considered](#). *Cureus*. 2023;15(12):e49955. doi:10.7759/cureus.49955
- <sup>32</sup> Karadag AS, Takci Z, Ertugrul DT, et al. [The effect of different doses of isotretinoin on pituitary hormones](#). *Dermatology*. 2015;230(4):354-359. doi:10.1159/000375370
- <sup>33</sup> Marino A, Albanese I, Larose S, Fantus IG. [Combined Central Hypothyroidism and Adrenal Insufficiency Associated with Retinoic Acid Therapy for Cutaneous T-Cell Lymphoma](#). *AACE Clin Case Rep*. 2022;8(6):251-254. doi:10.1016/j.aace.2022.08.004
- <sup>34</sup> Wolfram M, Bellingrath S, Kudielka BM. [The cortisol awakening response \(CAR\) across the female menstrual cycle](#). *Psychoneuroendocrinology*. 2011;36(6):905-912. doi:10.1016/j.psyneuen.2010.12.006
- <sup>35</sup> Ozgocer T, Ucar C, Yildiz S. [Cortisol awakening response is blunted and pain perception is increased during menses in cyclic women](#). *Psychoneuroendocrinology*. 2017;77:158-164. doi:10.1016/j.psyneuen.2016.12.011

- 
- <sup>36</sup> Tell D, Mathews HL, Janusek LW. [Day-to-day dynamics of associations between sleep, napping, fatigue, and the cortisol diurnal rhythm in women diagnosed as having breast cancer](#). *Psychosom Med*. 2014;76(7):519-528. doi:10.1097/PSY.0000000000000097
- <sup>37</sup> Paschali M, Lazaridou A, Paschalis T, et al. [Individual variation in diurnal cortisol in patients with knee osteoarthritis: Clinical correlates](#). *Int J Psychophysiol*. 2021;167:1-6. doi:10.1016/j.ijpsycho.2021.06.004
- <sup>38</sup> Summers SJ, Keegan RJ, Flood A, et al. [The Acute Readiness Monitoring Scale: Assessing Predictive and Concurrent Validation](#). *Front Psychol*. 2021;12:738519. doi:10.3389/fpsyg.2021.738519
- <sup>39</sup> Hall DL, Lattie EG, Antoni MH, et al. [Stress management skills, cortisol awakening response, and post-exertional malaise in Chronic Fatigue Syndrome](#). *Psychoneuroendocrinology*. 2014;49:26-31. doi:10.1016/j.psyneuen.2014.06.021
- <sup>40</sup> Høgh S, Lange EØ, Høgsted ES, et al. [The cortisol awakening response is blunted in healthy women early postpartum](#). *Psychoneuroendocrinology*. 2024;165:107048. doi:10.1016/j.psyneuen.2024.107048
- <sup>41</sup> Mikolajczak M, Quoidbach J, Vanootighem V, et al. [Cortisol awakening response \(CAR\)'s flexibility leads to larger and more consistent associations with psychological factors than CAR magnitude](#). *Psychoneuroendocrinology*. 2010;35(5):752-757. doi:10.1016/j.psyneuen.2009.11.003
- <sup>42</sup> Lai JCL, Leung MOY, Lee DYH, et al. [Biomarking Trait Resilience With Salivary Cortisol in Chinese Undergraduates](#). *Front Psychol*. 2020;11:536510. doi:10.3389/fpsyg.2020.536510
- <sup>43</sup> Rausch J, Gäbel A, Nagy K, et al. [Increased testosterone levels and cortisol awakening responses in patients with borderline personality disorder: gender and trait aggressiveness matter](#). *Psychoneuroendocrinology*. 2015;55:116-127. doi:10.1016/j.psyneuen.2015.02.002
- <sup>44</sup> Elder GJ, Wetherell MA, Barclay NL, Ellis JG. [The cortisol awakening response--applications and implications for sleep medicine](#). *Sleep Med Rev*. 2014;18(3):215-224. doi:10.1016/j.smrv.2013.05.001
- <sup>45</sup> Nater UM, Maloney E, Boneva RS, et al. [Attenuated morning salivary cortisol concentrations in a population-based study of persons with chronic fatigue syndrome and well controls](#). *J Clin Endocrinol Metab*. 2008;93(3):703-709. doi:10.1210/jc.2007-1747
- <sup>46</sup> Fransson E, Folkesson L, Bergström M, et al. [Exploring salivary cortisol and recurrent pain in mid-adolescents living in two homes](#). *BMC Psychol*. 2014;2(1):46. doi:10.1186/s40359-014-0046-z
- <sup>47</sup> Melia CS, Soria V, Salvat-Pujol N, et al. [Sex-specific association between the cortisol awakening response and obsessive-compulsive symptoms in healthy individuals](#). *Biol Sex Differ*. 2019;10(1):55. doi:10.1186/s13293-019-0273-3
- <sup>48</sup> Leggett AN, Liu Y, Klein LC, Zarit SH. [Sleep duration and the cortisol awakening response in dementia caregivers utilizing adult day services](#). *Health Psychol*. 2016;35(5):465-473. doi:10.1037/hea0000276
- <sup>49</sup> Devine JK, Wolf JM. [Determinants of cortisol awakening responses to naps and nighttime sleep](#). *Psychoneuroendocrinology*. 2016;63:128-134. doi:10.1016/j.psyneuen.2015.09.016
- <sup>50</sup> Saridjan NS, Kocavska D, Luijk MPCM, et al. [The Prospective Association of the Diurnal Cortisol Rhythm With Sleep Duration and Perceived Sleeping Problems in Preschoolers: The Generation R Study](#). *Psychosom Med*. 2017;79(5):557-564. doi:10.1097/PSY.0000000000000440
- <sup>51</sup> Deer LK, Shields GS, Alen NV, Hostinar CE. [Curvilinear associations between family income in early childhood and the cortisol awakening response in adolescence](#). *Psychoneuroendocrinology*. 2021;129:105237. doi:10.1016/j.psyneuen.2021.105237
- <sup>52</sup> Leneman KB, Donzella B, Desjardins CD, et al. [The slope of cortisol from awakening to 30 min post-wake in post-institutionalized children and early adolescents](#). *Psychoneuroendocrinology*. 2018;96:93-99. doi:10.1016/j.psyneuen.2018.06.011

- <sup>53</sup> Smyth N, Thorn L, Hucklebridge F, et al. [Detailed time course of the cortisol awakening response in healthy participants](#). *Psychoneuroendocrinology*. 2015;62:200-203. doi:10.1016/j.psyneuen.2015.08.011
- <sup>54</sup> Smyth N, Clow A, Thorn L, et al. [Delays of 5-15 min between awakening and the start of saliva sampling matter in assessment of the cortisol awakening response](#). *Psychoneuroendocrinology*. 2013;38(9):1476-1483. doi:10.1016/j.psyneuen.2012.12.013
- <sup>55</sup> Smyth N, Thorn L, Hucklebridge F, et al. [Assessment of the cortisol awakening response: Real-time analysis and curvilinear effects of sample timing inaccuracy](#). *Psychoneuroendocrinology*. 2016;74:380-386. doi:10.1016/j.psyneuen.2016.09.026
- <sup>56</sup> Lin YH, Jen HJ, Lin YK, et al. [Cortisol Awakening Response and Stress in Female Nurses on Monthly Shift Rotations: A Longitudinal Study](#). *Biomed Res Int*. 2022;2022:9506583. doi:10.1155/2022/9506583
- <sup>57</sup> Lindholm H, Ahlberg J, Sinisalo J, et al. [Morning cortisol levels and perceived stress in irregular shift workers compared with regular daytime workers](#). *Sleep Disord*. 2012;2012:789274. doi:10.1155/2012/789274
- <sup>58</sup> Griefahn B, Robens S. [The cortisol awakening response: a pilot study on the effects of shift work, morningness and sleep duration](#). *Psychoneuroendocrinology*. 2008;33(7):981-988. doi:10.1016/j.psyneuen.2008.04.004
- <sup>59</sup> Grosser L, Knayfati S, Yates C, et al. [Cortisol and shiftwork: A scoping review](#). *Sleep Med Rev*. 2022;64:101581. doi:10.1016/j.smrv.2021.101581