HPA-D: Etiology – Part 2

Okay, circadian disruption is the next factor. As we talked about in the basic physiology section, the HPA axis is inexorably intertwined with mechanisms that control the circadian rhythm and vice versa. These rhythms are constantly entrained by the 24-hour light–dark cycle, which all life on Earth evolved, and things like sleep deprivation, working the night shift, using electronic media at night, air travel and jet lag, and working indoors with minimal daytime light exposure have a profound impact on the HPA axis. This at least in part explains the connection between these lifestyle patterns and metabolic disorders, cancer, cognitive decline, and other health problems. So let's look at each of these in a little more detail.

Within the category of circadian disruption, sleep deprivation's probably the most significant issue for most people. Sleep loss negatively affects mood and emotional processing and leads to significantly higher subjective experiences of stress. It's also been shown to increase cortisol levels. For example, sleep restriction in firefighters is associated with increased levels of interleukin-6, TNF alpha, and interleukin-10, which involve inflammatory cytokines, as well as cortisol levels. Another study found that sleep problems may place adolescents at risk for HPA axis hyperreactivity to stress, which contributes to academic, behavioral, and health problems. And yet another study found that overweight men with sleep apnea had significantly higher levels of cortisol and lower levels of testosterone.

Exposure to light has a profound influence on the HPA axis. For the vast majority of our evolutionary history, we lived in harmony with the natural rhythms of day and night, without exposure to artificial light. We were physically active throughout the day and rested at night, we didn't have access to stimulants like caffeine and tobacco, we didn't have cell phones, computers, tablets, video games, and other electronic devices. There's no doubt that artificial light has many benefits: it's extended the length of the productive day and made all kinds of recreational activities possible at night that weren't possible before, but this does not come without consequences. In fact, some researchers have used the term light pollution to describe the harmful effects of artificial light on both animal and human physiology, and they've argued that light pollution is by far the most pervasive and damaging form of pollution of all forms of pollution, when you look at the research. Almost everyone in modern society uses artificial light to extend light into the evening or before sunrise in the morning, and whatever the benefits of this are, it's far outside of the evolutionary norm for humans, and even current practice in much of the developing world, where people get 12 hours of exposure to darkness whether they're sleeping or not.

So why is artificial light such a potential problem for the HPA axis and human health? Environmental light is the strongest influence on the circadian system, and light exposure has been shown to shift the natural human biological clock. For example, exposure to artificial light in the evening or night hours can delay sleep onset, and light exposure during the day affects sleep quality and duration during the night. Exposure to light at the wrong times, like at night, and lack of exposure to light at the right times, in the morning or during the day, can alter our circadian

rhythm, which in turn has profound impacts on pretty much every aspect of our physiology. The human retina has two types of light-sensitive cells that contribute to vision: rods, for vision under low-light conditions, and cones, for color vision under higher-light conditions. However, a new type of light-sensitive cell in the retina was recently discovered that doesn't contribute to vision at all; instead, it has multiple effects on biological function, most notably on the secretion of melatonin by the pineal gland.

Nighttime light exposure suppresses the production of melatonin, which disrupts the HPA axis. Melatonin suppression has also been shown to increase the risk of cancer, impair immune function, and possibly lead to cardio-metabolic consequences like type 2 diabetes, metabolic syndrome, obesity, and heart disease. Short-wavelength or blue light is the most melatonin-suppressive, and this is the type of light typically emitted by devices such as televisions, computer screens, cell phones, and tablets. To produce white light, these electronic devices must emit light at short wavelengths close to the peak sensitivity of melatonin suppression. This means that products like tablets, smartphones, and other devices with self-luminous electronic displays are major sources for suppressing melatonin at night, which reduces sleep duration and disrupts sleep.

This is a huge problem, because 95 percent of Americans report using some type of electronics at least a few nights a week within the hour before bed. Forty-seven percent of college students reported nighttime waking to answer text messages and 40 percent to answer phone calls. This kind of behavior reduces average sleep time each night by at least 45 minutes, which is especially problematic because the students were already getting less sleep, about seven hours per night, than studies suggest that college students need for optimal function, which is nine-and-a-quarter hours. A study of 710 university students aged 17 to 25 years found that over 70 percent of those who accessed the internet between 7 p.m. and 12 a.m. slept poorly. Electronic media exposure in children and adolescents, especially those who keep a media device in the bedroom, is associated with later bedtime and shorter sleep duration, so this really is an epidemic, especially among teenagers and college-age kids.

Along with blue light emitted from electronic devices, research has shown that even being exposed to normal levels of room lighting can have a similar negative impact on melatonin and the HPA axis. One study showed that an hour of moderately bright light exposure at 1,000 lux was sufficient to suppress nocturnal melatonin to daytime levels. Since melatonin suppression is intensity-dependent, researchers suggest that lower intensities can have similar suppression effects at longer durations. For example, two hours at 500 lux would have a similar effect as one hour at 1,000 lux. This means that typical room light alone can have similar suppressing effects on melatonin secretion as the light from backlit screens.

In addition to too much exposure to light at night, most people in the modern world are not getting enough exposure to light during the day. This puts us into a state of what you might call light deficiency. Outdoor light is far more intense than indoor light. Light intensity is measured in lux units, and on any given day, the outdoor lux units would be about around 100,000 at noon. Indoors, the typical average is somewhere between 100 to 2,000 lux units, basically two orders of magnitude less than outdoor light. Bright light exposure during the day helps to regulate cortisol

levels and balance the HPA axis, and this anchor light, as it's referred to, anchors your circadian rhythm, causing it to be less fragile, so that light at night has less of an ability to shift your rhythm. The first 30 to 60 minutes of outdoor light exposure creates about 80 percent of that anchoring effect. So just going outside for about half an hour at lunchtime or in the morning can provide you with the majority of anchoring light you need to maintain a healthy circadian rhythm.

Jet lag is another modern phenomenon that alters the natural circadian clock. Chronic jet lag, which is associated with ongoing travel across time zones, has been shown to decrease sleep quality, reduce cognitive function, raise cortisol levels—a sign of stress of course—and even increase the risk of cancer due to disturbances of melatonin levels. In fact, rates of prostate and breast cancer are 40 to 70 percent higher in male and female flight personnel, respectively.

Shift work is a new characteristic of our 24/7 lifestyle made possible by artificial light. About 20 percent of the population in the industrialized world now works beyond the normal day shift in various schedules of shift work. Our bodies are hardwired to be in sync with the natural rhythms of day and night. Shift work causes a continual disruption of the circadian light–dark cycle. Shift workers are required to remain awake when their bodies are physiologically preparing for sleep and are required to sleep when performance, alertness, and core body temperature are on the rise. Night shift workers experience shortened subsequent daytime sleep and more objective than subjective measures of sleepiness. Morning shift workers get less sleep because they have to wake up earlier and they feel more tired throughout the day. The worst kind of shift work is an alternating shift, where someone might work the night shift two days a week and then a day shift another two or three days a week. Studies suggest that those who are on a consistent shift, like people working the night shift every day, may be able to adapt somewhat, but an alternating shift is just a complete disaster for the HPA axis. It's been shown that it's nearly impossible to adapt to that, and it causes the most severe disruption of melatonin and other biomarkers of HPA axis function, and unfortunately, this alternating shift is very common in emergency services work like police and fire departments, although there is some increasing awareness about the problem here, and there is a move, at least in some areas, to switch people to a more consistent shift. If you have a patient and they are struggling with HPA axis dysfunction and related pathology and they're doing an alternating shift, you have to have a pretty honest conversation with them about the effect of that kind of work on their health, and ultimately, it will be up to them to determine whether they're able to make a career change or at least lobby for a consistent shift at work. Of course, we realize as clinicians that it's not easy for people to make a career change, and there are a lot of intervening factors, but I believe it's our responsibility, especially since they're coming to us with the expectation that we're going to help them with their health problems, to explain how that kind of alternating shift work is contributing and just to be honest and upfront, that it may not be possible to recover their health as long as they're doing that kind of alternating shift work.