CPH News and Views

A semi-monthly column on emerging topics related to healthy workplaces

Issue # 11: Shift Work – Working against our Internal Clocks

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The circadian rhythm is a pattern of approximately 24 hours with characteristic physiologic and metabolic cycles of, among many other attributes, body temperature, hormone secretion, sleep/wake cycle, alertness, and gene expression (Takahashi et al., 2008). Impressively, this rhythm has been shown to persist indefinitely in a constant dark environment that contains no other time cues; 'approximately' means that under constant dark conditions the rhythm is typically a little longer than 24 hours. The genetic components of a ~24-hour clock are found in all organisms so far studied, from cyanobacteria to human beings, with few exceptions.

The circadian rhythm can be entrained by light and dark. For our ancestors the cycle was kept precisely at 24 hours by the natural cycle of exposure to sunlight. In modern electrically lit societies, however, many if not most people suffer some degree of disruption of the circadian rhythms by exposure to light at night and by inadequate exposure to sunlight, especially in the morning. This is particularly acute for people who work on non-day shifts.

It is widely accepted that the risk of breast cancer is both increasing in industrial societies and rapidly increasing in the developing world. In the mid-1980s, Stevens (1987, 2009a) proposed that increasing use of artificial lighting might explain part of this trend, in that electric light at night can suppress production of melatonin by the pineal gland. Melatonin is a hormone naturally produced by the body which is known to be protective against breast cancer in rodents and may also be so in humans. Normally, melatonin production is 5 to 20 times higher at night in the dark than during the day, but this normal night-time elevation is suppressed by exposure to artificial light. If true, this theory would also imply a similar effect of light at night for the risk of prostate cancer in men.

One of the first and most obvious implications of this theory was that persons working night shifts would be at higher risk of these specific cancers than would day-working persons (Stevens, 2009b). Studies since that time have produced a limited but quite consistent group of epidemiologic studies, many of which were among nurses, and a strong animal model of carcinogenesis following disruption of the circadian rhythm (Blask et al., 2005). This evidence has now advanced to the point where the International Agency for Research on Cancer has concluded that "shift-work that involves circadian disruption is probably carcinogenic to humans (Group 2A)" (Straif et al., 2007).

Meanwhile, new research in the field of genetics has shown that there may be other relevant mechanisms, besides melatonin production, which are also controlled by the genes involved in maintaining the circadian rhythm (Stevens et al., 2007; Haus and Smolensky, 2006).

Given the large and growing proportion of the population employed in non-day shift work, this effect of night work could account for many cases of cancer (breast and prostate, and perhaps others). Current estimates of the relative risk of cancer range from 1.5 to 2.5 for non-day shift workers, compared to day workers. It is important to emphasize that these risk estimates of the total societal impact are conservative, i.e., the effect may be stronger than we can document in current studies. This is because the comparison groups are necessarily day-workers who live in modern societies and who certainly do not go to dark at sunset, and who may also often start the work day before sunrise.

One recent study (Burch et al., 2005) confirmed that night workers had altered melatonin excretion, disrupted sleep, and greater symptom (e.g., 'feeling tired', 'not alert', etc.) prevalence compared to day workers. This study also showed that when workers were ranked on their sleep to work urinary 6-sulphatoxymelatonin ratio, this ratio was a better predictor of adaptation than shift worked. In a normal healthy day worker, the sleep:work ratio is between 5 and 20, whereas for non-day workers the ratio is often close to 1. A ratio close to or less than one was highly predictive of disrupted sleep and symptom prevalence in Burch's study. This innovative metric provides a new tool for investigating shift and personal factors that most strongly disrupt circadian rhythms and thereby, perhaps increase the risk of two of the most common cancers in people, breast and prostate.

For many environmental or occupational exposures, the mechanism by which they cause disease doesn't matter so much because the exposure can be reduced or eliminated. However, if shift work does cause disease, then the mechanism is crucial to understand for the purposes of intervention and mitigation. This is because shift work is going to increase, not decrease, as more and more of world commerce operates on a 24-hour basis, and as the use of electric lights at night spreads in developing countries. Thus we need to identify new ways to protect shift-workers from the health risks of their jobs. Given our advancing understanding of the biology of circadian rhythms and of how light affects that rhythm, the scientific and architectural lighting communities should work together to design shift schedules and the lighting of non-day shift environments that better accommodate circadian health: this could involve for example,new lighting technologies that alter the wavelength and intensity of the luminaire over the course of the non-day shift.

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He has graduate training in Epidemiology and experience in many aspects of cancer research from cellular, toxicological, clinical, and observational epidemiology

Recommended journal articles:

Blask DE, Brainard GC, Dauchy RT, et al. Melatonin-depleted blood from premenopausal women exposed to light at night stimulates growth of human breast cancer xenografts in nude rats. Cancer Res 65:11174-84, 2005.

Burch JB, Yost MG, Johnson J, Allen E. Melatonin, Sleep, and Shift Work Adaptation. JOEM 47:893-901, 2005.

Haus E, Smolensky M. Biological clocks and shift work: circadian dysregulation and potential long-term effects. Cancer Causes Control 17:489-500, 2006.

Stevens, RG: Review and Commentary: Electric power use and breast cancer: a hypothesis. Am Epidemiol 125:556-561, 1987.

Stevens RG, Blask DE, Brainard GC, Hansen J, Lockley SW, Provecio I, Rea MS, Reinlib L. Meeting Report: The role of environmental lighting and circadian disruption in cancer and other diseases. Environ Health Perspec, 115:1357-62, 2007.

Stevens RG. Light-at-night, circadian disruption and breast cancer: assessment of existing evidence. Int J Epidemiol Apr 23. [Epub ahead of print], 2009a

Stevens RG. Electric light causes cancer? Surely you're joking, Mr. Stevens. Mutat Res Jan 16. [Epub ahead of print], 2009b.

Straif K, Baan R, Grosse Y, Secretan BE, Ghissassi FE, Bouvard V, Altieri A, Benbrahim-Tallaa L, Cogliano V. Carcinogenicity of shift-work, painting, and fire-fighting. Lancet Oncol 8:1065-1066, 2007.

Takahashi JS, Hong HK, Ko CH, McDearmon EL. The genetics of mammalian circadian order and disorder: implications for physiology and disease. Nat Rev Genet 9:764-75, 2008.

CPH-NEW
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