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Lighting

Nonvisual effects

by Lennart Wetterberg, MD, PhD¹

WETTERBERG L. Lighting: nonvisual effects. *Scand J Work Environ Health* 1990;16(suppl 1):26—8. The rhythmic variations of several hormones in man have been shown to be regulated by changes in the environmental light-dark cycle. In experiments with environmental lighting conditions the seasonal variation and the latitude of the study may influence the results. The nonvisual effect of light has recently been used for treating affective disorders. The clinical improvement of some depressed patients from the use of evening bright-light therapy may be related to an effect of light on the melatonin-rhythm generating system.

Key terms: bright light, depression, jet lag, melatonin, pineal gland, radioimmunoassay, seasonal variation.

The nonvisual cues of light exerts its effect on the human neuroendocrine function in a rhythmic, circadian-like fashion. One hormone which has a clear 24-h variation and which is tied to the biological clock is the hormone melatonin from the pineal gland. Åkerstedt et al (1) showed already 10 years ago that melatonin urinary excretion, body temperature, and subjective arousal¹ continued during 64 h of sleep deprivation when healthy persons were kept in dim light (lower than 25 cd/m²) and unaware of the chronological time. The melatonin-rhythm generating system (see figure 1) thus shows a biological rhythm which continues in low light for at least 2 d. Somewhat stronger light suppressed the nocturnal increase in melatonin in healthy controls in Sweden (2) at a latitude of 59° north. Lewy et al (3) reported that they needed 2500 lx to suppress melatonin when the experiment was done at a latitude of 38° north. Bojkowski et al (4) from England found that most people responded to partial suppression of melatonin with 300 lx when the experiment was performed at a latitude of 51° north.

I mention these differences because they indicate that the results of the effects of light on hormonal concentration and rhythms are influenced by environmental light and that different luminance may exert different effects when studies are done in different seasons and at different latitudes.

Neuroendocrine changes in affective disorders

Depression belongs to the affective disorders and is a state of mind with a distinct quality of depressed mood.

Several biological measures have been claimed to be potentially helpful as trait markers in depression, to indicate a constitutional (genetic) vulnerability to affective disorders, or as state markers related to the severity of the disease state. Two of the most used tests for state markers are the dexamethasone suppression test and the thyroid-stimulating hormone response to thyrotropin-releasing hormone.

Melatonin as a possible marker for a subgroup of depression

New diagnostic trends emphasize the importance of early biological markers for the different subtypes of depression to enable one to choose the right drug for the individual patient. The basis for the interest in melatonin in affective disorders was a report by Wetterberg et al (5) in which higher cortisol levels were seen during depression than during recovery and the peak level of melatonin occurred earlier during the disease state.

The potential use of melatonin as a marker in depression was obvious. Not only is melatonin dependent on both noradrenergic and serotonergic neuronal systems for its regulation, but melatonin also seems to be related to the hypothalamic-pituitary-adrenal axis, which has been shown to be affected in depressive states. In addition, melatonin is useful in indicating both the phase and the amplitude of the biological clock. The variation in melatonin concentration over a 24-h period allowed scientists to study the hypothesis of free-running rhythm failure in subtypes of depression and to test the phase advance theory of affective illness introduced in 1968 by Halberg (6). This theory is based on the possibility of an internal and external desynchronization of physiological functions. Temporal external desynchronization, as in jet lag, occurs in some individuals during flights over time

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zones, and rapid time-zone changes may even precipitate affective illness in predisposed persons, as Jauhar & Weller (7) showed in London in a study at Heathrow Airport.

Melatonin and seasonal variations

Seasonal variations in the incidence of depression, suicide, and the use of antidepressive therapy are well documented (8, 9). Circannual rhythms in pineal function in animals have been reported over the last two decades, and a seasonal variation in pineal gland weights in human autopsy material has been described ((2). Seasonal variations in melatonin production, measured as 24-h serum levels, have also been shown, at least at some latitudes (10, 11). Serum and plasma melatonin determinations may thus be of interest in relation to different disease states and diagnostic subgroups.

To follow-up early findings of a possible relationship between the pineal gland and adrenal glands, Wetterberg et al (12) reported that low melatonin was related to high cortisol and an abnormal dexamethasone suppression test. The current views of melatonin as a tool in the diagnosis of mental diseases in general was reviewed in 1988 by several authors in the monograph *Melatonin, Clinical Perspectives* (13). Specific findings relating serum melatonin to clinical variables in patients with depression have also been reported (14–16).

Factors other than light influencing melatonin concentration

It is clear that factors other than changes in the light-dark cycle are of importance for melatonin levels. It has been reported that age (17–22), body weight (23, 24), body height (14), the use of glasses (25), drugs (26),

and genetic variation (27) are among factors which in different degrees and under different circumstances may influence melatonin levels in humans. Different types of medication and sampling conditions may also influence melatonin concentrations. In our studies the melatonin radioimmunoassay from KALAB (Danville, California, United States) was used for measuring the melatonin concentration of serum and urine.

Melatonin in depressed patients: effects of light exposure

In previous reports it has been shown that the exposure of healthy persons to a luminance of 350 cd/m² for 1 h between 2200 and 2300 causes a significant suppression of serum melatonin levels followed by a “rebound” to higher melatonin levels later in the night (28). The same experimental paradigm was applied to 12 psychiatric patients with a major depressive episode. In this group the light exposure caused a significant suppression of melatonin levels at 2300; however, there was less rebound effect (29). Eight of these depressed patients were treated with bright light with a luminance of 350 cd/m² between 1800 and 2000 for 10 d. Some of the depressed patients were rated as improved, while the others did not respond to light therapy. In the responders the suppression of the serum melatonin level by the 1-h exposure to light was significant both before and after the light therapy. The melatonin peak appeared to be shifted to later in the night, and the serum melatonin levels were diminished after the 1 h exposure to light following the light therapy.

In summary, bright light has shown, in several studies, to be effective in the treatment of some but not all patients with depression. One attractive theory is that light operates as a time cue to reestablish a normal circadian rhythm in depressed patients whose biological clock is out of phase (30, 31).

Figure 1. The melatonin rhythm-generating system includes the eye, the hypothalamus, and the neuronal pathway to the pinealocytes. Changes in the environmental light-dark cycle regulate the enzymatic transformation of the neurotransmitter serotonin to the pineal hormone melatonin. The rhythmic variation in hormone secretion in humans may be influenced by artificial bright light in the evening with the maximal effect occurring for 350 cd/m². (NSC = nucleus suprachiasmaticus, SUP = superior, SCG = superior cervical ganglia, NA = noradrenaline, β-ADR = beta adrenergic receptor, cAMP = cyclic adenosine monophosphate, ATP = adenosine triphosphate, AA = amino acids, 5-HTP = 5-hydroxytryptophan, NAT = N-acetyltransferase, N-Ac-5-HT = N-acetyl-5-hydroxytryptamine, HIOMT = hydroxyindole-O-methyltransferase)

Another question which needs more attention is how healthy persons perform and feel under different natural light-dark cycles and how manipulation of the environmental lighting in the workplace affects a person's life. New results have provided a theoretical model and a challenge which involves extensive international collaboration to study the effect of light on health and performance. Such studies are called for and have to be carried out at many latitudes. Some are already under way. For those interested in light therapy, an international society for light treatment and biological rhythms has been formed to help to solve some of the many remaining questions involved in the nonvisual effects of light.

References

- Åkerstedt T, Fröberg JE, Friberg Y, Wetterberg L. Melatonin excretion, body temperature and subjective arousal during 64 hours of sleep deprivation. *Psycho-neuroendocrinology* 1979;4:219—25.
- Wetterberg L. Melatonin in humans. *J Neural Transm Suppl* 1978;13:289—310.
- Lewy AJ, Wehr TA, Goodwin FK, et al. Light suppresses melatonin excretion in humans. *Science* 1980; 210:1267—9.
- Bojkowski C, Aldhouse ME, English J, et al. Suppression of nocturnal plasma melatonin and α -sulphatoxy-melatonin by bright and dim light in man. *Hormon Metab Res* 1987;19:437—40.
- Wetterberg L, Beck-Friis J, Aperia B, et al. Melatonin/cortisol ratio in depression. *Lancet* 1979;2:1361.
- Halberg F. Physiologic considerations underlying rhythmometry, with special reference to emotional illness. In: de Ajuriaguerra J, ed. *Cycles biologiques et psychiatrie: Symposium Bel-Air III*. Geneva: Masson et Cie, 1968:73.
- Jauhar P, Weller MPI. Psychiatric morbidity and time zone changes: a study of patients from Heathrow airport. *Br J Psychiatry* 1982;140:231—5.
- Eastwood MR, Peacocke J. Seasonal patterns of suicide, depression and electroconvulsive therapy. *Br J Psychiatry* 1976;129:472—775.
- Rosenthal NE, Sack DA, Wehr TA. Seasonal variations in affective disorders. In: Wehr TA, Goodwin FK, ed. *Circadian rhythms in psychiatry*. Pacific Grove, CA: The Boxwood Press, 1983:185—201.
- Arendt J, Wirz-Justice A, Bradtke J. Annual rhythm of serum melatonin in man. *Neurosci Lett* 1977;7:327—30.
- Wirz-Justice A, Arendt J. Diurnal, menstrual cycle and seasonal indole rhythms in man and their modification in affective disorders. In: Obiols J, Ballus C, Gonzales E, Monclus E, Pojul J, ed. *Biological psychiatry today*. Amsterdam: Elsevier, 1979:294—302.
- Wetterberg L, Aperia B, Beck-Friis J, et al. Pineal-hypothalamic-pituitary function in patients with depressive illness. In: Fuxe K, Gustafsson JA, Wetterberg L, ed. *Steroid hormone regulation of the brain*. Oxford: Pergamon, 1981:397—403.
- Miles A, Philbrick DR, Thompson C, ed. *Melatonin, clinical perspectives*. Oxford: Oxford University Press, 1988: 253—79.
- Beck-Friis J, von Rosen D, Kjellman BF, et al. Melatonin in relation to body measures, sex, age, season and the use of drugs in patients with major affective disorders and healthy subjects. *Psychoendocrinology* 1984;9: 261—77.
- Beck-Friis J, Kjellman BF, Aperia B, et al. Serum melatonin in relation to clinical variables in patients with major depressive disorders and a hypothesis of a low melatonin syndrome. *Acta Psychiatr Scand* 1985;71: 319—30.
- Claussrat B, Chazot G, Brun J, et al. A chronobiological study of melatonin and cortisol excretion in depressed subjects: plasma melatonin, a biological marker in major depression. *Biol Psychiatry* 1985;19:1215—28.
- Iguchi H, Kato KI, Ibayashi H. Age-dependent reduction in serum melatonin concentrations in healthy human subjects. *J Clin Endocrinol Metab* 1982;55:27—9.
- Sharma M, Palacios-Bois J, Schwartz G, et al. Circadian rhythms of melatonin and cortisol in aging. *Biol Psychiatry* 1989;25:305—19.
- Thomas DR, Miles A. Melatonin secretion and age. *Biol Psychiatry* 1989;25:365—7.
- Toutiou Y, Fèvre M, Lagoguey M, et al. Age- and mental health-related circadian rhythms of plasma levels of melatonin, prolactin, luteinizing hormone and follicle-stimulating hormone in man. *J Endocrinol* 1981;91: 467—75.
- Waldhauser F, Waldhauser M. Melatonin and aging. In: Miles A, Philbrick DR, Thompson C, ed. *Melatonin, clinical perspectives*. Oxford: Oxford University Press, 1988:174—89.
- Wetterberg L. Clinical importance of melatonin. *Progr Brain Res* 1979;52:539—47.
- Arendt J, Hampton S, English J, et al. 24-hour profiles of melatonin, cortisol, insulin, C-peptide and gip following a meal and subsequent fasting. *Clin Neuroendocrinol* 1982;16:89—95.
- Felner IN, Arendt J, Johnstone EC, et al. Reduced nocturnal melatonin secretion in chronic schizophrenia: relationship to body weight. *Clin Endocrinol* 1968;17: 181—7.
- Erikson C, Küller R, Wetterberg L. Non visual effects of light. *Neuroendocrinol Lett* 1983;5:412.
- Thompson C, Mezey G, Corn T, et al. The effect of desipramine upon melatonin and cortisol excretion in depressed and normal subjects. *Br J Psychiatry* 1985; 147:389—93.
- Wetterberg L, Iselius L, Lindsten J. Genetic regulation of melatonin excretion in urine. *Clin Genet* 1983;24: 403—6.
- Beck-Friis J, Borg G, Wetterberg L. Rebound increase of nocturnal melatonin levels following evening suppression by bright light exposure in healthy men: relationship to cortisol levels and morning exposure. In: Wurtman RJ, ed. *The medical and biological effects of light*. Ann NY Acad Sci 1985;453:371—5.
- Kjellman BF, Beck-Friis J, Borg G, et al. Nighttime melatonin in depressed patients; effects of one hour light exposure and light therapy. *Psychopharmacology* 1988; 96(suppl):114. [Abstract, Colloquium Internationale Neuro-Psychopharmacologicum.]
- Healy D. Rhythm and blues: neurochemical, neuropharmacological and neuropsychological implications of a hypothesis of a circadian rhythm dysfunction in affective disorders: review. *Psychopharmacology* 1987;93: 271—85.
- Kripke DF. Phase-advance theories for affective illness. In: Wehr TA, Goodwin FK, ed. *Circadian rhythms in psychiatry*. Pacific Grove, CA: Boxwood Press, 1983: 41—69.