

Fatigue, Sleep and Seasonal Hormone Levels: Implications for Drinking Behavior in Northern Climates

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INTRODUCTION

Many seasonal phenomena, such as amount of daylight, correlate with latitude. Suicide (Lester, 1970) and seasonal depression (Booker & Hellekson, 1992) are examples of two behaviors that have been reported at higher prevalence levels in northern latitudes. A high rate of alcohol abuse has also been noted in northern regions (London & Teaque, 1985; Segal, 1991). Research (Segal, 1991; Segal & Duffy, 1992) in Alaska, for example, has shown extraordinary high levels of drinking among a street population of homeless drinkers. A small proportion (7.7%) drank at a mildly intoxicated

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level, a larger proportion (23%) drank at an intoxicated level, and more than two-thirds (69.3%) drank at either a highly intoxicated level (37.4%), or at a severely intoxicated level (31.9%). Similar results have been noted in Siberia (Korolenko & Botchkareva, 1990).

Melatonin, the hormone of darkness (Reiter, 1991), has been correlated with the amount of daylight, and may be related to suicide and depression (Waldhauser et al. 1993). Mortality related to violent causes, including suicide, is also higher than normal in the north (Hobart, 1976; Bjerregaard & Juel, 1990). Furthermore, it can be theorized that chronic alcoholism may be related to a pathological process that involves long-term changes in physiology associated with changes in melatonin levels (Blum, 1990).

In the last decade, the study of brain function has led to hypotheses that postulate a relationship between neurotransmitter and hormone levels and alcoholism and substance abuse (Blum, 1990). Such neurobiological studies attempt to bridge the gap between the molecular and behavioral levels, with emphasis on the interrelations of genetics, neurotransmitters, hormones, such as melatonin, and conditioned responses in addictive drug action.

Melatonin, produced in the pineal gland, is normally secreted at night, with peak levels at about 0200. This hormone is sensitive to light impulses, with inhibition of secretion normally initiated by the reception of light impulses received through the retina (Reiter, 1993). Morning (0800) melatonin levels have been studied during the winter in Stockholm, Sweden, and have remained elevated to greater than twice those reported during summer at the same time of day (Beck-Friis et al. 1984). Large-scale studies of normal populations in northerly latitudes have not been reported.

An epidemiological study of seasonal affective disorder (SAD) in the high latitude community of Fairbanks, Alaska, found that 8.9% of the sample reported symptoms consistent with SAD. Sixty-seven percent of the respondents reported a "marked" or "extreme" change in energy level between summer and winter, with one-half of those reporting a weight gain of 10 pounds (4.5 kg) or more (Booker & Hellekson, 1992). The present study represents a preliminary test of the hypothesis that extreme, but normal, season-

al hormone variations, are correlated with fatigue changes as reported by Booker and Hellekson (1992). This relationship has important implications for the treatment of alcoholism in the north.

METHOD

Subjects

The study population consisted of 43 male volunteers who were infantry soldiers at Ft. Wainwright, Alaska. The average age was 20.4 years (SD = 2.5). The average duration of stay in Alaska, at the outset of the year-long study, was 10.8 (SD = 5) months. The mean height was 1.8 m, and mean weight was 75 kg (SD = 9). All but two participants were single and lived in the Army barracks. The racial composition was 34 Caucasians, 8 African Americans, and 1 Hispanic. Birth places of subjects varied, with a tendency of under representation from the southeastern and southwestern United States. Only one subject was born in Alaska. All participants were screened for health problems and medications, and also for travel out of Alaska during the study period. They were also administered a brief Recent Events questionnaire.

Psycho-Neuroendocrine Protocol

The study was designed to measure levels of depression and certain endocrine levels during the four seasons of the year in the sub-Arctic. In actuality these seasons are not typical, with spring and autumn usually very brief, lasting only about 1.5 months each. Summer usually lasts for about 3 months, and the winter snow cover lingers for about 7 months. Blood samples were drawn around the time of the solstices and equinoxes, on 21 June 1991, 21 September 1991, 21 December 1991, and 21 March 1992. Dates of taking samples were either on the solstices or equinoxes or within 5 to 10 days of them, with the exception of the Vernal equinox, where a few samples were not drawn until over 3 weeks following the equinox.

Blood samples for melatonin, cortisol, and testosterone were obtained at four separate times during the study days: at 0200, 0800,

1030, and at 1700. Serial Beck Depression Inventories (Beck, 1967) as well as the Life Events questionnaires were also obtained on those days, usually after the 1030 sampling of blood.

To maintain as natural an environment as possible, especially at the time of the 0200 samplings, subjects were instructed to use no more light than absolutely necessary when getting out of bed and reporting to the venipuncture area. They also were instructed to put on their sunglasses, which are standard issue to infantry soldiers. Barracks halls were maintained in a dimly lighted condition, as was the waiting area and the venipuncture areas, which were in the barracks dayrooms or battalion aid stations. Measurements of the light in these areas was performed using a Triple Range 214 Light Meter by General Electric. Brightness in these areas where soldiers were exposed was never greater than 400 Lux, and that level of intensity was only experienced for very brief periods, usually when passing for only seconds directly under a fluorescent bulb illuminating a stairwell. For most of the time between arousal and venipuncture, which was usually only a matter of minutes (up to 15 to 30 at most) the level of luminosity ranged from 0 to 200 Lux.

Hormone Assays

Melatonin levels were measured in the laboratory of the Institute of Arctic Biology at the University of Alaska Fairbanks, which is located approximately 15 km from Ft. Wainwright. Blood samples were transported by motor vehicle on the day of the drawing, after periods of up to several hours of refrigeration at Community Mental Health Services, also at Ft. Wainwright, as practiced in an earlier study (Levine et al. 1994). Only samples that showed no or minimal evidence of hemolysis were utilized.

Cortisol determinations were also performed at Madigan Army Medical Center in Washington by means of a radioimmunoassay obtained from Diagnostic Systems Laboratories, Inc., Webster, Texas. All cortisol determinations were done in duplicate.

Testosterone determinations were also performed at the Madigan Army Medical Center by means of a radioimmunoassay obtained from ICN Biomedicals, Inc., Diagnostics Division. All testosterone determinations were done in duplicate. This determination detects the total unconjugated form of this steroid. This method does not

distinguish between protein (albumin and sex hormone binding globulin), bound testosterone and true free testosterone, which must be measured after a dialysis procedure.

Psychological Screening

All subjects were administered a single Seasonal Pattern Assessment Questionnaire (SPAQ) at the start of the study. This is an 18 item, self-administered questionnaire, which addresses symptoms of SAD; weather preferences, weight fluctuations, variations in sleep duration, food preferences, and the question of whether seasonal changes presents a problem (Rosenthal, 1989).

Data derived from the SPAQ were analyzed in several ways, primarily with an overall estimated score. The score was developed from a total of all responses to Item 12, which consists of 6 factors, each scored in a range of 0-4. The Item 12 factors are sleep length, social activity, mood (overall feeling of well being), weight, appetite, and energy level.

Following the criteria of Rosenthal (1989), all subjects were scored in a range from 0-24, as follows:

- | | |
|-------|----------------------------------------------------|
| 0-7 | Normal, average, or non-SAD |
| 8-10 | Subsyndromal Seasonal Affective Disorder (Sub-SAD) |
| 11-24 | Seasonal Affective Disorder (SAD) |

To make a definite diagnosis of SAD, a "yes" response to Item 18 "Do you feel that these seasonal changes are a problem for you?" was required, in addition to an overall score of 11 or more. Also, there were a large number of subjects who reported frequent symptoms of enough severity to classify them, by score only (on Item 12), as possible sub-syndromal SAD, or potentially SAD.

Additionally, all subjects were administered the Beck Depression Inventory (BDI) on the days of each seasonal venipuncture. The Beck Inventory is a 21 item self-administered questionnaire, which has been widely used in clinical psychiatry. The inventory contains four possible responses to each of 21 items, and can usually be completed within 5 to 15 minutes.

RESULTS

Psychological and Behavioral Characteristics of Subjects

The SPAQ was completed by 45 subjects. The mean score on seasonal changes (Item 12) was 9.4 (SD = 4.5), which is in the upper range for possible sub-syndromal SAD (see Table 1). The breakdown of the group, by score on Item 12 shows that nearly 35% of the subjects were affected by season.

An increase in time spent sleeping was noted in winter. Sleep duration varied significantly by 1.9 hours when summer was compared to winter ($p = 0.002$) by the paired t -test. Spring and autumn sleep duration did not vary significantly (see Table 2).

Two-thirds of the study group reported weight fluctuations of greater than 3 pounds (1.3 kg) during the course of the year (see Table 3).

Question 14 on the SPAQ addressed the effects of the weather on changed mood. About 30% (13 of 43) of the soldiers indicated very low spirits or being markedly slowed down by cold weather. Also, 60.5% indicated a marked improvement of mood or energy level associated with sunny days. Beck Depression Inventories adminis-

TABLE 1. Scores on SPAQ Seasonal Changes (Item 12).

Score	N	%
0-7 (Normal)	16	37.2%
8-10	12	27.9%
11-24 (affected)	15	34.9%

TABLE 2. Mean Sleep Duration by Season.

Season	Hours	S.D.
Summer	6.55	2.578
Autumn	7.57	1.860
Winter	8.44	1.980
Spring	7.44	1.881

tered quarterly, yielded mean scores in the mildly depressed range (see Table 4).

Among 9 cases for which Beck Inventories were available for all seasons, there was a suggestive, but non-significant trend towards increasing depression in autumn and winter with improvement in spring. This lack of significance may have been due to the small sample size.

Physiological Characteristics

Seasonal fluctuations in mean levels from these subjects were reported for melatonin and other hormones (Levine et al. 1994). Melatonin levels at 0800 and 1030 varied significantly between summer and winter values, when measured by ANOVA ($p < 0.001$) at both time points. Additionally, melatonin collected at 1700 was significantly elevated in winter, and a phase shift in amplitude was observed in winter samples. Plasma melatonin levels were positive-

TABLE 3. Annual Weight Fluctuation of 43 Soldiers.

Pounds	N	Percent
0-3	14	32.6%
4-7	11	25.6%
8-11	9	20.9%
12-15	6	13.9%
16-20	2	4.6%
> 20	1	2.3%

TABLE 4. Beck Depression Inventory: Group Mean by Season (ANOVA).

Season	N	Mean	S.D.
Summer	42	6.976	4.921
Autumn	30	6.600	8.665
Winter	24	6.417	6.940
Spring	18	4.722	6.304

ly correlated with fatigue during winter at 0200 (Pearson $r = .56$) and at 1030 ($r = .40$). Change in energy levels (SPAQ Item 12F) showed a stronger interrelationship with melatonin at 0800 (Pearson, $r = .75$).

DISCUSSION

Sleep duration and change in energy level, as well as fatigue (Item 17) on the BDI, were significantly correlated with melatonin levels. Sleep duration, as reported by season (Item 16 on the SPAQ) is a linear, self-reported measure and showed significant correlations with melatonin levels at a specific season. These correlations must be interpreted cautiously, in that hormone levels were drawn at the solstices and equinoxes, which would not necessarily correspond exactly with the seasons in Alaska, as perceived by subjects with a short time in the north. Testosterone shows a correlation with sleep duration in winter whereas melatonin levels appear to be interrelated with sleep duration in the summer.

Similarly, winter levels of melatonin were correlated with fatigue, and also with change in energy level (Factor F on Item 12 on the SPAQ). This is noteworthy because other factors such as social activity, as well as total SPAQ score, showed significant relationships. Nevertheless, because of a small sample size, this correlation must be viewed with caution. Currently, the importance of melatonin in the regulation of appetite and nutritional state of animals is being reassessed (Huether, 1993).

This study reinforces previously reported findings from a larger community sample. Changes in energy level, reported by Booker and Hellekson (1992), on a Fairbanks, Alaska population, were highly significant, and correlated with sleep duration. Melatonin secretion patterns appear to play a significant role in the long-term regulation of the important adrenocortical and reproductive hormone secretion levels, which in turn are associated with psychological and behavioral effects.

It is well documented that darkness can affect neurotransmitter function. Moreover, it was shown that laboratory rats, when living in total darkness for over two weeks, developed a strong preference for alcohol (Geller, 1971). Melatonin interacts with the neurotrans-

mitter systems that are involved in reward and craving (dopamine and serotonin), and has been shown to affect fatigue, sleep, eating behavior and the immune system (Waldhauser et al. 1993). Our results support the hypothesis that high latitude light cycles may lead to a biochemical imbalance in predisposed individuals that contributes to feelings of unwellness. Alcohol can provide a momentary adjustment of the neurochemical system while inducing a feeling of relief or euphoria.

These findings suggest that because of the contribution of the underlying endocrine substrate to fatigue and sleep, which is seasonal, fatigue may be partially treated by photoperiod modification or by modulation of melatonin levels. Bright light has been shown to lower resting metabolic rate in patients with SAD compared to that of controls (Goist et al. 1990).

A relationship between melatonin, alcohol metabolism (Blum, 1990) and drinking behavior has been explored. Specifically, drinking levels were found to be related to extended periods of light and darkness, with more drinking occurring during darkness (Blum, 1990). It has also been hypothesized that there is a relationship between melatonin and alcohol metabolism (Blum, 1990). Thus, drinking and its effects, including absorption, metabolism, excretion and interaction, may vary with season. It may thus be necessary, in northern climates, to begin to explore if treatment for SAD, or adjustment of melatonin levels, are necessary treatment adjuncts to help an individual to break dependence on alcohol. Light therapy, for example, is an easy and inexpensive process that has been shown to treat SAD. The inclusion of light therapy, in cases of known clinical SAD depressions and alcoholism, may help to correct underlying physiological anomalies that may hinder recovery.

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