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Evening melatonin in January after changes in hours of habitual exercise during fall among youths living in the Subarctic

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Abstract

Secretion of the hormone melatonin shows a circadian rhythm and is inhibited by light. Light therapy with phase shifting of the melatonin rhythm has been used as treatment of sleeping problems and seasonal affective disorders (SAD). Exercise has also been shown to suppress the melatonin secretion. In order to investigate the effect of increased level of habitual physical activity upon melatonin secretion in areas with extreme short days and high level of midwinter insomnia, 18 high school students participated in this study. Their habitual physical activity throughout two consecutive falls were recorded. The following January, blood samples were taken for melatonin analyses from 1530h to 2300h. After the fall with highest habitual activity level, the plasma melatonin showed significantly decreased values at all sampling times compared to values after lowest level of activity. The relative increase in melatonin level at 2300h, however, tended to be of a greater magnitude after the fall with highest activity compared to the fall with lowest activity ($p=.094$). A change in habitual level of activity should be thought of as a possible help for treating midwinter insomnia and SAD.

Parts of Norway are north of the arctic circle, which means that during a year there are periods when the sun does not rise above the horizon for several weeks (called the "darkness period") and a period during which the sun does not set for several weeks. Several reports claim that sleeping problems increase during the "darkness period" (1-3). The lack of an entraining effect of normal daylight is assumed to affect the normal biological rhythms (4). There is a reason to believe that recurrent winter depressions are precipitated by the seasonal decline in natural light (5). The illness is referred to as

Seasonal affective disorder (SAD). Patients with SAD frequently complain of sleep abnormalities during the winter months (6). Light therapy has been found to help patients with SAD (7) and midwinter insomnia (1). The antidepressant effect of light depends on correcting abnormally phased circadian rhythms of melatonin (the phase shift hypothesis) (7, 8). It is also shown that patients with long term sleeping problems have been cured after oral intake of melatonin (9-11).

Instead of getting medication or special light therapy, an idea was borne to see if it was possible to phase shift the melatonin

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secretion rhythm by changing the life style, as for instance the level of habitual physical activity.

Studies have shown conflicting results about the influence of exercise upon melatonin secretion. Some (12-14) reports an increase of the acute melatonin response to exercise, while others (15,16) reports a decrease of melatonin. The stimulating exercises have varied in intensities (12,14), types and durations (13, 16, 17,18) or in the time of day the stimulating exercise took place (16). The subjects have differed in fitness (15), and stage of menstrual cycle (19). Some studies have used only men (17,20,21) others only women (12, 14, 15). Studies analyzing for sex differences have however, reported no sex influence upon mean serum melatonin levels at daytime or nighttime (22).

Monteleone et al. (16) found in a study using only men, that melatonin was suppressed if exercise was performed during the period when melatonin normally increased. This suppressing effect of exercise upon melatonin is also confirmed by Rivest et al. (20). They compared melatonin secretion at night after daily activity and total bed rest. Men secreted significantly more melatonin during the night in the rest than in the activity condition.

Could it be that the conflicting results concerning effect of exercise upon melatonin secretion is caused by an adaptation of melatonin secretion to the level of habitual exercise? Is it possible that the effect of exercise is reflected by a change in melatonin rhythm parameters, rather than the traditional melatonin parameters used to study acute effect of exercise?

The purpose of this study was to see if evening melatonin secretion in an environment with extremely short days, was influenced by a change in magnitude of habitual exercise during the preceding fall.

Materials and Methods

Experimental subjects

Eighteen high-school-students, 11 girls and 7 boys, 16-18 years old, living in Alta, Norway,

at the time of the study, voluntarily participated in the study. The students and their parents gave written consent to participate. The study was approved by the Norwegian Ethical Committee, region 5.

Only one girl and one boy were not borne in the region, they had however lived in the region 16 of their 18 years. All participants had lived in Alta the last 5 years prior to the study.

Information about work, health topics, as well as habitual physical activity were gathered in January 1989 and January 1990 using questionnaires.

Physical activity and fitness

Each subject's hours of habitual physical activity per week and information about background and lifestyles, were computed from the questionnaires for each fall.

Six of the participants, 2 girls and 4 boys, were members of the local European-handball team and participated in regular practice and matches. The others were not involved in competitive sports at the time of the study, but participated in physical activity classes at school. The second fall 10 of the subjects participated in a 30 minutes low intensity stationary biking program (exercise heart rate 143.6 ± 9) twice a week. Participation varied from one to 27 times, with a mean participation of 15.1 ± 9.4 times.

The subjects' physical fitness were evaluated using Åstrand's submaximal bicycle test (23). Tests were performed in December/January, 1988/89 and 1989/1990.

Lighting conditions

In Alta, Norway, (latitude $69^{\circ}56'N$; longitude $23^{\circ}22'E$) where this study was done, the sun is not visible above the horizon from November 26 to January 17. In this position the light will be reflected and cause dusk or dawn for a maximum of 6 hrs per day.

Blood sampling and hormonal assay

Blood samples for melatonin analysis were taken at 1530h, 1600h, 2100h, 2200h and 2300h in January 1989 and January 1990.

TABLE I. Physical Characteristics in January, after a fall with low and high level of habitual physical activity, and results from paired t-test for the Students performing tests both years (Means \pm SE).

	Habitual activity hrs pr week (N=15)	Aerobic capacity ml O ₂ /kgxmin (N=11)	Weight kg (N=16)
After fall with lowest activity	7.1 \pm 1.1	45.5 \pm 2.1	62.3 \pm 1.5
After fall with highest activity	8.7 \pm 1.3	47.5 \pm 1.9	62.3 \pm 2.2
t-value	2.59	-1.02	0.06
p-value	0.021	0.339	0.954

The subjects came to the laboratory on one out of two selected days, directly from school. In 1989 the blood samples were taken on 11th or 12th of January, while in 1990 the samples were gathered one week later, January 18th and 19th. The period of dusk/dawn is 45 minutes longer the sampling day in 1990 compared to the sampling day in 1989.

The subjects arrived the laboratory 20-30 minutes before the first blood sample was taken, and stayed at the lab until the second sample was taken. During this time the questionnaires were filled out. After the second sample they were free to do whatever they wanted except participate in physical activity other than walking around, and watching TV. The subjects met at the lab again at 2000h. Only dim wall lights (max 5 lux) were used during the evening, except for the short period when the blood samples were taken (max 300 lux). The subjects were very strongly instructed not to look directly at the light.

Vacutainers SST with gel and clot activator were used for the sampling. The samples stood 30 minutes to cool before centrifugation, then transferred to test tubes and immediately frozen at -20°C. Within 2 weeks the samples were moved to about -75°C and stored until they were analyzed. The blood samples

were analyzed using RIA after the method of Wetterberg et al. (24).

Analysis and statistics

All data were read into a database and analyzed using the computer programme SPSS/PC+. For each melatonin value two new values were computed a) the value expressed as percent of melatonin value at 1600h the same day, and b) the value expressed as percent of the melatonin value at 1600h after the fall with lowest activity.

Students t-test for paired observations for each timepoint was used to detect any differences in the effect of level of habitual physical activity. Analyses were performed for absolute melatonin values and the melatonin values expressed as percent of 1600h-value and as percent of 1600h-low-activity-value.

Results

Habitual physical activity and activity changes

Two participants (boys) had highest activity level the last fall (1989) and 13 participants (5 boys and 8 girls) had highest activity level the first fall (1988). Three participants (girls) showed no change in the habitual level of

physical activity, these subjects were not included in the further analyses. Blood samples at some timepoints were missing for some subjects, because of that the number of subjects at each timepoint is less than 15. Hours of habitual activity per week and physical characteristics are shown in Table I. There was no significant increase in the aerobic capacity even if the level of physical activity showed a significant increase ($p=0.021$).

Melatonin alterations

The concentrations of plasma melatonin are shown in Fig. 1. After the fall with highest habitual activity level, the plasma melatonin show decreased values at all sampling times compared to values after lowest level of activity (at 1600h $p<0.01$, at the other sampling times $p<0.05$). When expressing the plasma concentrations as percent of the value at 1600 h, there are no longer any significant difference between melatonin levels at the same timepoints. The relative increase in melatonin level at 2300h tend to be of a greater magnitude after the fall with highest activity compared to fall with lowest activity. The difference,

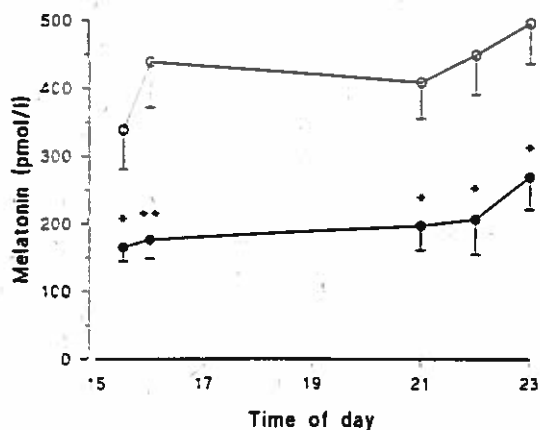


Fig. 1. Concentration of plasma melatonin (\pm SE) during evening and early night in January, after falls with changes in habitual level of physical activity. Open circles: melatonin concentration after fall with lowest activity level. Closed circles: after fall with highest activity level. * = significant difference, $p<0.05$; ** = $p<0.01$

however, is not significant ($p=0.094$). When expressed as percent of value at 1600h the year after fall with lowest activity level, the melatonin levels after fall with highest level of habitual activity, are lowered at all timepoints, but the decrease is only significant at 1600h ($p=0.004$).

Discussion

This study confirms what have been found in other studies (17,20) where the effect of exercise stress has been investigated. The secretion of melatonin seems to be suppressed by increased physical activity, short term as well as an increased level of habitual physical activity.

Since the present study did not turn out to be a cross-over-study as planned, but mostly a study with decreased level of habitual activity from year one to year two, it can not be claimed that it is only the effect of increased physical exercise level that causes the suppression of melatonin secretion. Other stress and changes might influence the results, such as the testing situation itself which probably was greatest the first year. The combined effect of lower level of habitual physical exercise and a familiar situation creates lower total stress which could have a smaller impact on the melatonin secretion, and in that way create a higher level of plasma melatonin. When melatonin level is expressed as percent of melatonin level at 1600h the same day, the difference in amount of total stress is corrected. Unfortunately we were unable to follow the melatonin secretion for 24 hours. Therefore it is impossible to evaluate the total circadian rhythm, any form of phase shifting and also the time for and magnitude of peak secretion. Such information would have given much better knowledge of the influence of changed habitual exercise level upon melatonin secretion.

In the present study a significant increase in aerobic capacity could not be documented, even if participation in activity (hrs in activity) had increased. This means possibly that the intensity of the performed activity was too

low to have any training effect. It shows that it is not a change in physical fitness and intensity that has influenced the melatonin secretion, but rather time spent in physical activity and the gross expenditure of energy, as others also have suggested (25).

In this study, only the fact that there was a change in the level of physical activity was of interest. There is a possibility that the level of activity in itself is of importance and (or) that the magnitude of change of the physical activity might be of relevance. It might be needed to look at this in another study.

The fact that the students all become one year older and gained weight should not be of any great concerns considering what others (26, 27, 28) report.

The small change in amount of daylight on the day of blood sampling from year one to year two seems to be of no influence since the light was around noon time, when the subjects are inside at school. This should not have any crucial influence on evening melatonin secretion, according to reports from Lewy et al. (29).

The reality that vacutainers with gel and clot activator were used for sampling the blood, are of greater worry according studies done by Wetterberg (30). Since the same type of vacutainers were used both years, it is hoped that the data still are valid and reliable, even if the time from sampling till analyzes differed.

In spite of the methodological problems, I conclude that an increase in level of habitual physical activity during a fall season will suppress melatonin secretion in January. Any influence upon circadian rhythm and peak secretion can not be drawn from the present study, but the results might indicate an increased relative peak level with increased level of habitual physical activity.

Since it seems that a change in habitual activity level might influence melatonin secretion, a change in habitual level of activity should be thought of as a possible help for treating midwinter insomnia and SAD.

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