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CHARACTERISTICS OF THE RADIATION CONDITIONS IN SELECTED GEOGRAPHICAL REGIONS

Charakterystyka warunków radiacyjnych w wybranych regionach geograficznych

Streszczenie. W artykule zaprezentowano wstępne wyniki badań wpływu warunków radiacyjnych na produkcję melatoniny (MEL) w organizmie człowieka. Badania prowadzone były w trzech regionach geograficznych o zróżnicowanych warunkach klimatycznych (Polska, Japonia i Wietnam). Melatonina przekazuje informacje o warunkach oświetleniowych do zegara biologicznego człowieka, a ten steruje pracą całego organizmu.

Największe sezonowe zróżnicowanie sum promieniowania całkowitego oraz aktywnego fotosyntetycznie (PAR) występowało w Polsce (rys. 2), w tym regionie stwierdzono również największą zmienność wydzielania melatoniny.

W ciągu dnia (godziny 7–16) największa częstość bardzo jasnych impulsów światła (> 1000 lux), na które ochotnicy byli eksponowani, z wyjątkiem okresu zimowego, pojawiła się w Polsce (rys. 3).

Zaobserwowano również zróżnicowanie widma promieniowania słonecznego między badanymi obszarami oraz w sezonach. W Polsce pik długości fali promieniowania docierającego w każdym sezonie występował w zakresie 451–500 nm, w Japonii w zakresie 501–550 nm. W Wietnamie wiosną i zimą występował w zakresie 651–700 nm, latem i jesienią w zakresie 501–550 nm.

Key words: global solar radiation, light intensity, spectral characteristics of solar radiation, wavelength, melatonin (MEL)
Słowa kluczowe: promieniowanie całkowite, intensywność oświetlenia, charakterystyki spektralne promieniowania słonecznego, długość fali, melatonina (MEL)

INTRODUCTION

Solar radiation has a great impact on the functioning of the human body, particularly on the processes of thermoregulation (Blazejczyk et al. 1999) and hormonal secretion (Zawilska, Nowak 2002). A significant correlation between lighting conditions and the pineal gland hormone – melatonin (MEL), which stimulates the endogenous human biological clock is observed as well (Karasek 1997). Melatonin production and secretion is connected mainly with dark phase (maximum of production is observed during the night). Previous researches were conducted on humans usually in one location only, with no comparison to others, so the environmental impact were no investigated. After MEL rhythm comparisons among three populations (Polish, Japaneese and Vietnamese) some significant differences were seen (Morita et al. 2002; Blazejczyk et al. 2005). A detail discussion of the causes of MEL concentration changes in the body, which is depended on the lighting conditions (natural and artificial) requires an examination of the characteristics of solar radiation in areas where the sample were collected.

The purpose of the paper is to present the characteristics of the radiation conditions in 3 geographical regions, which represent various climate zones: Poland (moderately warm transient climate), Japan (marine subtropical monsoon climate) and Vietnam (tropical monsoon climate). The results obtained in this investigation will be helpful to find which characteristics of solar radiation and lighting stimuli could be the reason of MEL secretion differentiation among populations. All calculations are based on data collected during the melatonin experiment in the period 2005–2007.

MATERIALS AND METHODS

The research were carried out at three base regions: Poland (Warsaw, 52°N), Japan (Fukuoka, 33°N) and in Vietnam (Hanoi, 21°N) four times a year: in Spring and Autumn equinox as well as in Winter and Summer solstice. The experimental period was from Monday to Friday. In each experiment young male and female (21–33 years) take part (Poland – 15, Japan – 18, Vietnam – 15). Participants were required to sleep from 23:00 until 7:00 in total darkness and to take they ordinary activity during the day.

During whole experiment, several outdoor environmental parameters were registered automatically every 1 minute: intensity of global (0.4–3.0 μm) and visible (0.4–0.76 μm) solar radiation, photosynthetically active radiation (PAR) as well as air temperature and humidity (by HOBO Micro Station). Spectral characteristics of solar light (irradiation, CCT, peak wavelength) were measured additionally several times a day (by LightSpex, GretagMacbeth).

Furthermore for each volunteer individual characteristics of: light intensity (with the use of ActiWatch, Mini Mitter Comp., Inc) and totals of energy of visible radiation in 7 spectral ranges the volunteers were exposed (HandyLight) data were controlled. To examine radiation impact at melatonin secretion saliva samples were collected simultaneously with measured solar radiation characteristics.

RELSULTS

The studied areas were significantly differentiated by lighting conditions (Fig. 1). Difference in maximum Sun altitude between Poland (Warsaw) and Vietnam (Hanoi) location were more than 20 degrees. Day length at Spring and Autumn equinox was similar (about 12 hours) at each location. The greatest seasonal differences in day length were observed for Warsaw. The longest day (22 of June) lasted 16 h 47 min while the shortest only 7 h 42 min (22 of December).

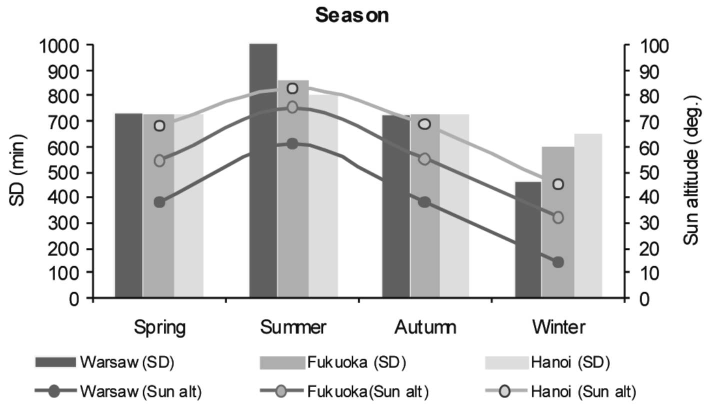

Fig. 1. Seasonal values of environmental factors at studied locations: day length (SD, min) and Sun altitude (degrees)
Ryc. 1. Charakterystyki sezonowe czynników środowiskowych na badanych obszarach: długość dnia (SD) i wysokość Słońca (w stopniach)

Those differences, which are related to geographical location have significant impact at solar radiation totals and in consequence affect the functioning of the human body, especially melatonin rhythm.

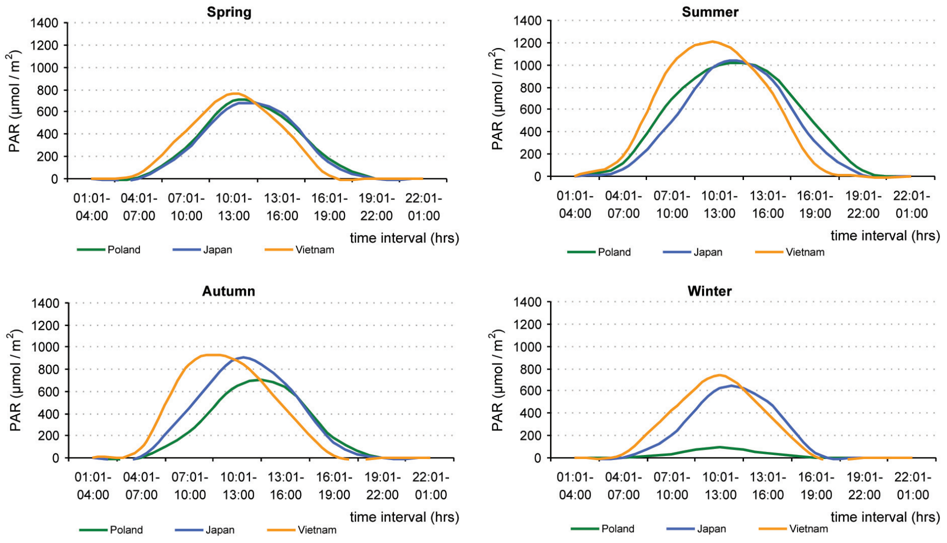

Fig. 2. Seasonal mean values of photosynthetically active radiation (PAR) at studied locations, µmol·m^{-2}

Ryc. 2. Średnie sezonowe wartości promieniowania aktywnego fotosyntetycznie (PAR) w badanych miejscach, µmol·m^{-2}

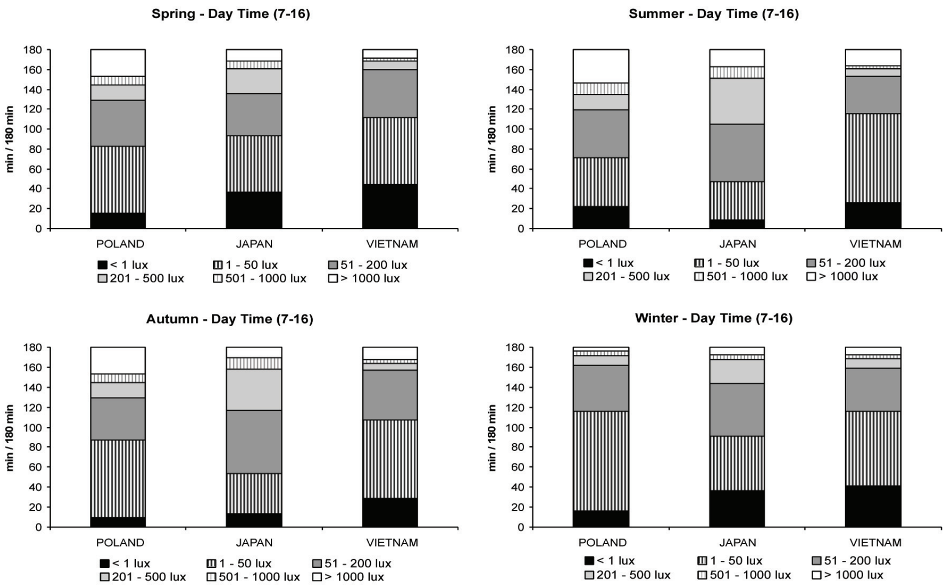

Fig. 3. Mean seasonal light intensity (lux) during the day time (7–16 hrs) at studied locations

Ryc. 3. Średnie sezonowe natężenie oświetlenia (lux) w ciągu dnia (godz. 7–16) w badanych miejscach

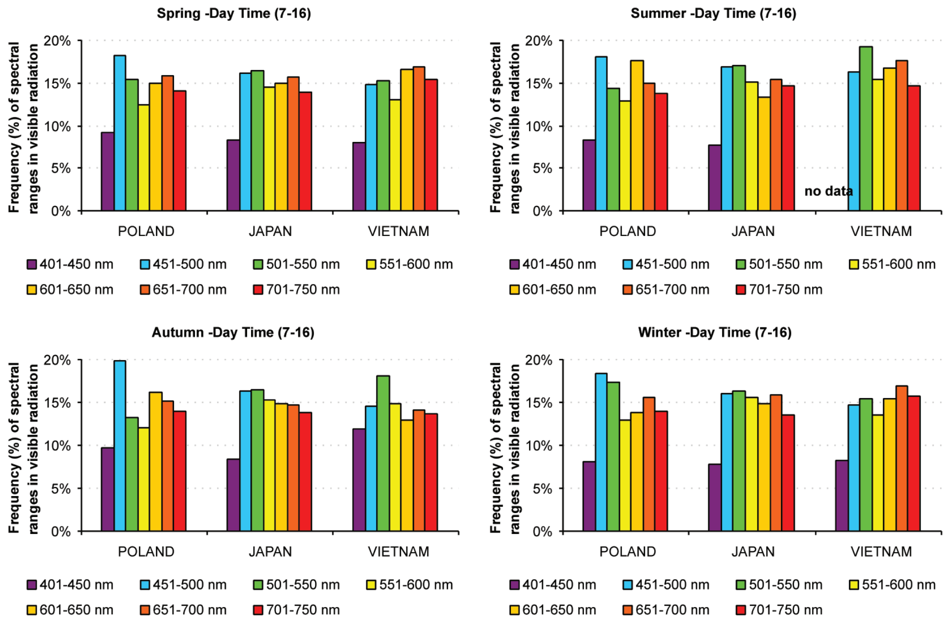

Fig. 4. Mean seasonal frequency (%) of spectral distribution of solar radiation at studied locations
Ryc. 4. Średnia sezonowa częstość (%) widma promieniowania słonecznego w przedziałach w badanych miejscach

Global solar radiation intensity (GSI) measured during the experiment presented common distribution in seasons and among the localizations. This values for each location were comparable with a multiannual data (Blazejczyk 2005). The biggest seasonal variations of GSI daily amounts occurred in Poland. The biggest values of GSI at noon (totals in period 10–13) were observed in Poland (Warsaw) in Spring and Summer period, at Autumn and Winter in Japan (Fukuoka).

Figure 2 presents seasonal mean amounts of photosynthetically active radiation (400–710 nm) in 3 hours intervals during experiment time. The highest values at noon were observed for Vietnam in each season. In Poland seasonal differentiation of PAR was the biggest. Totals of PAR in the Summer were 20 times higher compared to the amounts occurred during the Winter Time of experiment. Maximum of PAR intensity usually occurred between 10 a.m. and 1 p.m. In Hanoi PAR maximum was observed earlier than in other locations.

Light intensity (lux) was studied in a 3 hour periods, in each period the number of light pulses (in 6 intervals) was calculated. Figure 3 presents mean light intensity conditions, which volunteers were exposed during the day time (hours 7–16). The highest frequencies of dark time (< 1 lux) were observed in

Vietnam and occurred in each season. The longest exposure to very bright light (> 1000 lux) in each season except Winter were observed for Poland. Autumn has proved to be more abundant in brighter light (> 50 lux) than Spring, what is the best exemplified in Japan.

During the experiment the differences in wavelength peaks were noted (Fig. 4). In Poland wavelength peak occurred in range 451–500 nm, which corresponded to blue light. In Japan in each season wavelength peak moved to the green light range. In Vietnam some seasonal differences was noted – in Spring and Winter the most frequent was wavelength in range 651–700 nm (near infrared). However, in Summer and Autumn wavelength of 501–550 nm (green light) prevailed.

CONCLUSION

Melatonin secretion differences among populations lives in various environmental conditions (representing different climate zones) which are confirmed by last investigations (experiment 2005–2007) are proof of significant impact of local lighting conditions at melatonin production. The biggest differences of MEL production in seasons are characteristic for locations with significantly differentiate solar radiations conditions. This confirms the biggest seasonal variability in PAR income in Poland (Fig. 2).

Typically melatonin diurnal profile with maximum secretion occurred at night (dark phase) may suggest that the biggest levels of the hormone should be characteristics for a season with the shortest photoperiod and the lowest solar radiation totals. Melatonin data, selected in each location do not confirm that suggestion. It seems that totals of solar radiation income during the day time (photic history) have a big impact of nocturnal MEL distribution. It is possible that strong doses of solar energy and increased light intensity during the day time could inhibit suppression of MEL caused by others factors (e.g. light pollution) during the night. The biggest frequencies of very bright light (> 1000 lux) impulses during the day time occurred in Poland, in each season (Fig. 3). In this location MEL secretion was the biggest (compared to other locations) in Spring and Summer, which were more abundant in brighter light than at this seasons in other studied areas.

In Spring PAR distribution in all locations was similar (Fig. 2) but MEL concentration was significant different. In Poland mean maximum of MEL was 63 $pg \cdot ml^{-1}$, in Japan 23 $pg \cdot ml^{-1}$ and in Vietnam 29 $pg \cdot ml^{-1}$. This differences in MEL levels could be the reason of solar radiation distribution in spectral ranges. In Spring in Poland wavelength peak occurred within the range of 451–500 nm, in Japan 501–550 nm when in Vietnam moved to near infrared, 651–700 nm (Fig. 4). In Poland and Japan MEL rhythm was similar in Spring and Summer. In Vietnam mean values of maximum MEL concentration was lower of 10 pg·ml^{-1}. In this period in Vietnam changes in spectral characteristics of solar radiation were seen. In Summer time with the biggest frequency occurred wavelengths of 501–550 nm. Different regional distribution of the incoming radiation in spectral ranges may be responsible for studied regional variations of melatonin concentration in man. Further studies should be conduced.

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