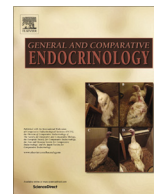




Contents lists available at ScienceDirect

General and Comparative Endocrinology

journal homepage: www.elsevier.com/locate/ygcen

Research paper

Human seasonal and circadian studies in Antarctica (Halley, 75°S)

Josephine Arendt*, Benita Middleton

Biochemistry and Physiology, Faculty of Health and Medical Sciences, University of Surrey, Guildford GU2 7XH, UK

ARTICLE INFO

Article history:

Received 30 March 2017

Revised 9 May 2017

Accepted 12 May 2017

Available online xxx

Keywords:

Seasonal

Circadian

Light

Melatonin

Antarctica

ABSTRACT

Living for extended periods in Antarctica exposes base personnel to extremes of daylength (photoperiod) and temperature. At the British Antarctic Survey base of Halley, 75°S, the sun does not rise for 110 d in the winter and does not set for 100 d in summer. Photoperiod is the major time cue governing the timing of seasonal events such as reproduction in many species. The neuroendocrine signal providing photoperiodic information to body physiology is the duration of melatonin secretion which reflects the length of the night: longer in the short days of winter and shorter in summer. Light of sufficient intensity and spectral composition serves to suppress production of melatonin and to set the circadian timing and the duration of the rhythm. In humans early observations suggested that bright (>2000 lux) white light was needed to suppress melatonin completely. Shortly thereafter winter depression (Seasonal Affective Disorder or SAD) was described, and its successful treatment by an artificial summer photoperiod of bright white light, sufficient to shorten melatonin production. At Halley dim artificial light intensity during winter was measured, until 2003, at a maximum of approximately 500 lux in winter. Thus a strong seasonal and circadian time cue was absent. It seemed likely that winter depression would be common in the extended period of winter darkness and could be treated with an artificial summer photoperiod. These observations, and predictions, inspired a long series of studies regarding human seasonal and circadian status, and the effects of light treatment, in a small overwintering, isolated community, living in the same conditions for many months at Halley. We found little evidence of SAD, or change in duration of melatonin production with season. However the timing of the melatonin rhythm itself, and/or that of its metabolite 6-sulphatoxymelatonin (aMT6s), was used as a primary marker of seasonal, circadian and treatment changes. A substantial phase delay of melatonin in winter was advanced to summer phase by a two pulse 'skeleton' bright white light treatment. Subsequently a single morning pulse of bright white light was effective with regard to circadian phase and improved daytime performance. The circadian delay evidenced by melatonin was accompanied by delayed sleep (logs and actigraphy): poor sleep is a common complaint in Polar regions. Appropriate extra artificial light, both standard white, and blue enriched, present throughout the day, effectively countered delay in sleep timing and the aMT6s rhythm. The most important factor appeared to be the maximum light experienced. Another manifestation of the winter was a decline in self-rated libido (men only on base at this time). Women on the base showed lower aspects of physical and mental health compared to men. Free-running rhythms were seen in some subjects following night shift, but were rarely found at other times, probably because this base has strongly scheduled activity and leisure time. Complete circadian adaptation during a week of night shift, also seen in a similar situation on North Sea oil rigs, led to problems readapting back to day shift in winter, compared to summer. Here again timed light treatment was used to address the problem.

Sleep, alertness and waking performance are critically dependent on optimum circadian phase. Circadian desynchrony is associated with increased risk of major disease in shift workers. These studies provide some groundwork for countering/avoiding circadian desynchrony in rather extreme conditions.

© 2017 Published by Elsevier Inc.

1. Introduction

Numerous human seasonal changes have been described in studies largely from temperate zones. However the extreme light

conditions, shared environment and closed community of an overwintering Antarctic base provide a natural laboratory for the observation and manipulation of seasonal changes (Arendt, 2012).

The most reliable seasonal time cue in temperate and high latitudes is changing daylength or photoperiod. Photoperiodic species, for example hamsters, sheep and goats, use primarily daylength to time seasonal functions such as reproduction, beha-

* Corresponding author.

E-mail addresses: arendtjo@gmail.com, j.arendt@surrey.ac.uk (J. Arendt), b.middleton@surrey.ac.uk (B. Middleton).

viour and coat growth. They perceive daylength changes by the duration of melatonin secretion from the pineal gland, longer in short days and vice versa. This mechanism was elucidated in the late 1970s – early 1980s (Carter and Goldman, 1983a,b; Arendt, 1986; Woodfill et al., 1991; Goldman, 2001). Since then considerable progress has been made regarding the downstream response in animals (Dardente, 2012; Lincoln and Loudon, 2015). However the question as to whether or not the profound reproductive and other seasonal changes as a function of photoperiod in such species also apply to some extent in humans has not been adequately answered. In humans, Seasonal Affective Disorder (SAD, winter depression) is probably the most closely linked to light conditions, being first observed in short days. It was initially treated, successfully, by artificially extending the winter daylength to a summer photoperiod using a 'skeleton' treatment (two light pulses), with extra bright light, sufficient to completely suppress melatonin secretion (Lewy et al., 1980) in the morning and the evening (Rosenthal et al., 1984). It appeared therefore that a human seasonal change was countered via a photoperiodic mechanism (although different theories are currently prominent).

In general the conservation of photoperiodic responses in humans in terms of melatonin secretion is difficult to address as it involves controlled long term imposition of particular environmental conditions. Where this was possible in temperate latitudes it was clear that changes in melatonin duration with imposed artificial photoperiod could occur in humans as they do in, for example, sheep, and they were linked to changes in duration of sleep and timing of sleep propensity (Wehr et al., 1993; Arendt, 1999; Vondrasová-Jelínková et al., 1999). The question of possible links with human reproductive function, mood and behaviour remains. There is certainly some evidence from pathology that circulating melatonin may relate to major changes in reproductive hormones e.g. (Arendt et al., 1989; Luboshitsky and Lavie, 1996; Walker et al., 1996).

Seasonal changes in the circadian timing system in humans are of closely related interest: the melatonin rhythm is the best way to date of assessing circadian timing (Klerman et al., 2002) and is extensively used for evaluating circadian status. The light-dark cycle, acting via retinal mechanisms, is the primary time cue for synchronisation of the suprachiasmatic nuclei (SCN), master pacemaker of the circadian system, to the 24 h day. In the absence of sufficient time cues circadian rhythms may delay or more rarely advance with respect to the 24 h day, or free-run (desynchronise completely from 24 h) showing endogenous periodicity. In humans this periodicity is individually variable, genetically determined, and on average slightly longer than 24 h (Czeisler, 1995; Middleton et al., 1996). A long endogenous period is more associated with subjective evening preference ('owl'), and a greater tendency to circadian delay, than a short period with morning preference ('lark') (Horne and Ostberg, 1976; Duffy et al., 2001). The amount of light needed to maintain circadian synchrony depends on different factors. In controlled long term (1 month) studies in an environment free of time cues with the exception of clock time, we found that a 12:12 light dark cycle of 200 lux: <8 lux white light was insufficient to maintain 24 h synchrony and that between 200 and 1000 lux was required (Middleton et al., 2002).

Much information on the use of light treatment to maintain synchrony has accumulated, including the importance of prior photoperiodic history (Hébert et al., 2002; Owen and Arendt, 1992), and the spectral quality of the light as well as its intensity and timing. The light phase response curve (PRC) – a measure of the magnitude and direction of phase shifts following a particular light stimulus – provides a means of predicting responses to timed light exposure (Czeisler, 1995; Chang et al., 2011; Rüger et al., 2013; Lucas et al., 2014). Providing circadian status is known or

predictable, light treatment can be timed to delay or advance the circadian system (see Fig. 1).

Other time cues (zeitgebers) include scheduled mealtimes, sleep, social interactions, exercise (Mistlberger and Skene, 2005). Combined with a weak light-dark zeitgeber they can help maintain synchrony. However the predominance of alternating light and darkness is most obvious in totally blind individuals, the majority of whom show the phenomenon of free-running. Here the circadian system displays its endogenous period in a normal light dark environment in the presence of all other possible time cues, (for early references see (Lockley et al., 2007). When such individuals attempt to conform to a 24 h day, awake during the daytime, sleeping at night, the deviation of the natural period from 24 h means that, intermittently, they will be out of phase with the internal clock attempting to sleep at a time of maximum alertness and work at a time of maximum sleepiness (Arendt et al., 1988; Sack et al., 1992; Lockley et al., 1999b, 2008). This has been referred to as a kind of recurrent jet lag, and is a lifetime problem. The most obvious symptoms in affected individuals are poor sleep and excessive daytime sleepiness/naps when out of phase. This phenomenon has been characterised as free-running sleep disorder (Morgenthaler et al., 2007). It was clearly described during the period when the sun is below the horizon (sundown) in four sighted over-winterers at Cape Evans base in Antarctica by Kennaway and van Dorp in 1991.

Circadian desynchrony, notably of shift workers has been associated with, poor sleep, lowered alertness and performance, and increased risk of major disease. The ability to maintain optimum circadian timing is of general importance to human health.

In view of the various light related phenomena described above it is clearly of interest to investigate human responses in different environmental and experimental light conditions. In 1984 the opportunity arose for the first author to design and supervise research in Antarctica on British Antarctic Survey bases with extreme environmental light changes during the year. The base doctor carried out the on-site sampling and recording, and data were analysed at the University of Surrey (with the help of Stockgrand Ltd, University of Surrey). Where possible the results formed the basis of an MSc in Remote Health Care and if suitable they were published. This short review summarises and discusses the relevant data.

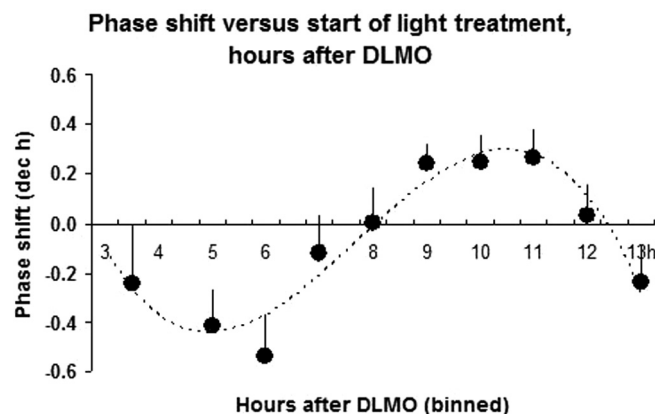


Fig. 1. An example of a light phase response curve (PRC). Relationship of phase shift (mean + SEM) of the melatonin rhythm to the timing of the start of one hour of light treatment (hours after dim light melatonin onset or DLMO, a circadian phase marker). The light source (500 nm) was 350 lux (irradiance 98 mW/cm² + 2%, manufacturer's measured specification: Sunnexbiotech.com). The photon density was 2.2×10^{14} photons/cm²/s. With DLMO at 21:00 h, 6 h after DLMO corresponds to 03:00 h clock time, etc. Reproduced from Paul et al., 2009, doi:10.1080/07420520903044331. PMID: 19637048.

Download English Version:

<https://daneshyari.com/en/article/8631293>

Download Persian Version:

<https://daneshyari.com/article/8631293>

[Daneshyari.com](https://daneshyari.com)