Impact of the solid angle of light sources upon the suppression of melatonin in adults - a feasibility study

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Kurzfassung

Es gibt mittlerweile viele Hinweise aus der Praxis, dass geeignete Lichtkonzepte für Senioreneinrichtungen oder für spezialisierte Pflegeheime für Menschen mit Demenz mehr als nur gutes Sehen ermöglichen. Dynamische Lichtsysteme helfen älteren Menschen ihren circadianen Rhythmus zu stabilisieren und Ihren Nachtschlaf zu verbessern. Somit kann auch Pflegekräften geholfen werden und womöglich können sogar Medikamente eingespart werden. Allerdings ist noch nicht klar wie und wie lange Licht mit geeignetem Spektrum auf den Menschen einwirken muss, um die gewünschten positiven Wirkungen zu erreichen. In dieser Vorstudie haben wir zwei Lichtszenarien verglichen, die eine Suppression von Melatonin beim Menschen in Abhängigkeit des Raumwinkels herbeiführen. Genaueres Wissen über den Zusammenhang inwieweit kleinflächiges Licht oder großflächiges Licht mit der gleichen Beleuchtungsstärke - gemessen am Auge - das körpereigene „Schlafhormon“ Melatonin unterdrückt ist wichtig um die richtige Lichtunterstützung für spezifische Situationen z. B. in oben genannten Einrichtungen planen zu können. Die Untersuchung von sechs Probanden lässt auf eine bessere Melatoninsuppression bei der Verwendung von großflächigen Lichtquellen gegenüber kleinen Lichtquellen schließen, die die gleiche Beleuchtungsstärke - gemessen am Auge - bewirken.

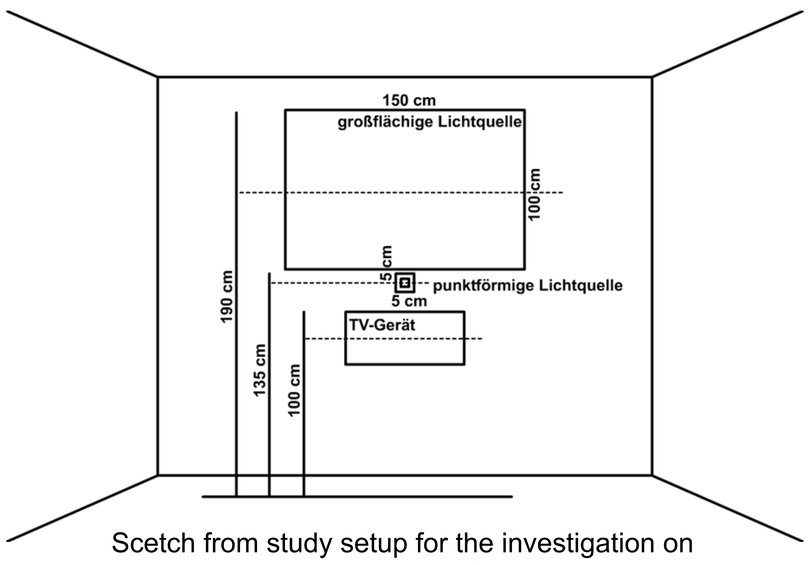
Abstract

In this feasibility study we intended to test the effect of exposure to different lighting scenarios upon the suppression of melatonin in adults in relationship to the solid angle in an experimental setting. High quality empirical and experimental deisgns are necessary in order to improve our knowledge about optimal lighting scenarios with regard to needs and demands of humans. Our experimental setup allowed us to investigate six participants under two different melatonin suppressing lighting conditions: a) a large solid angle, b) and a small solid angle (ie. how large the light source appears tothe observer). Results suggest that a large solid angle could be more effective for suppressing melatonin in humans.Further elucidation of the mechanisms could be useful for developing and designing lighting scenarios for residentialcare homes or other specialized caretaking facilities. Particularly specialized nursing homes for individuals sufferingfrom dementia could take advantage of with the optimal lighting scenarios, not only for the psychological and physicalhealth of their residents in care but in order to support the care takers.

Setup

N = 6 participants (1 female; 5 male) were tested in this pilot evaluation study. Participants were exposed to different lighting conditions by means of an experimental set-up for four hours in the late evening between 09:00 pm until 01:00 am. Participants were separated into two groups (A, B).

Exposure to the different lighting scenarios started at always 09:00 pm in the evening for both groups. Participants had to wear specific glasses with filters that blocked blue spectral parts of the ambient surrounding light. After an hour (at 10:00 pm) participants were told to remove the glasses, and a one hour wash-out phase was introduced from 10:00 pm to 11:00 pm, a washout phase (WO), where participants were solely exposed to light stemming from a television display. From 11:00 pm to midnight, group A was first exposed to the light source with the small solid angle and from midnight to 01:00 am exposed to the light source with the large solid angle. Group B was inversely exposed to the lighting scenarios, i.e. first exposed to the large solid angle and then to the small solid angle.



Scetch from study setup for the investigation on the solid angle

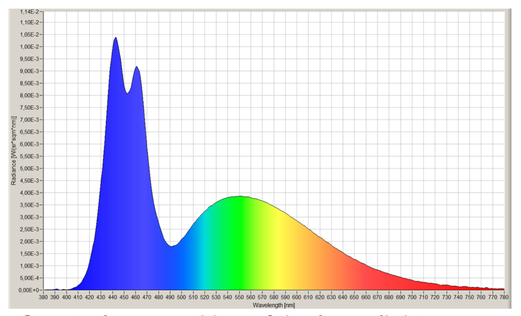
This permutation was requires in order to compensate for the nonlinearity of the natural melatonin secretion. The lighting exposure scenarios where randomly permuted to avoid order effects.

Saliva samples were taken to analyze and determine the melatonin level with a competitive enzyme immunoassay for the quantitative determination of melatonin (ELISA).

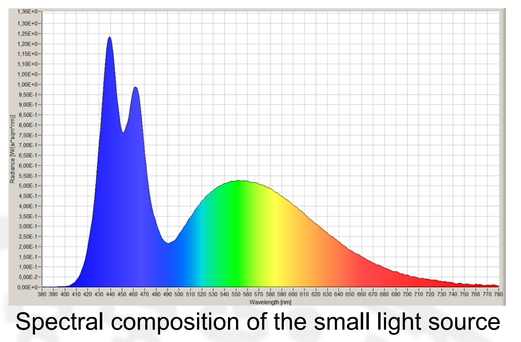
Technical details:

Large and small ligth sources with LEDs of type:
OSRAM "Golden DRAGON Plus" ultra white
Optical efficiancy (max): 146 lm/W at 100 mA
Color: x = 0.31, y = 0.32 (CIE 1931: white),
CTR = 6500 K

OSRAM "Golden DRAGON Plus" blue (B)
Optical efficancy (max): 35 lm/W at 100 mA
Color: blue (467 nm)



Spectral composition of the large light source



Spectral composition of the small light source

Method

To determine the impact of the light source and the moderating role of the specific solid angle on melatonin suppression, the gradient of a fitted line was calculated for each lighting scenario (washout phase and each light source) separately. We consider the gradient as a more stable value due to intra- and interindividual differences in indivuduals. In a next step, gradients of each lighting scenario were compared. The gradient can be interpreted as the first derivation of the rise in nocturnal salivary melatonin and is more comparable than absolute meltonin levels, considering different dim light melatonin onsets (DLMO) and absolute melatonin levels in individuals. Our hypothesis was that the gradient of the melatonin level in the experimental lighting scenarios with the hypothesized melatonin suppressing light sources should be negative or at least smaller than the respective gradients of the washout phase. Corresponding, the two lighting conditions with different solid angles were tested for difference in the gradients. After testing for normal distribution a T-test with paired samples was additionally calculated.

Result

Comparing the different gradients with each other by a paired samples T-Test, the following results were gained.

	Mean	SD	T	Diff Mean	Sign.
WO < > sSA	1,99	3,74	1,31	-1,99	,25
WO < > ISA	1,91	2,23	2,10	-1,91	,09
sSA < > ISA	-,081	4,28	-,047	0,08	,97

T-Test of the gradients, Significance level is p < ,05
small solid angle (sSA; Mean: 1,80) large solid angle (ISA; Mean 1,89)

Cohen's d sSA 0,58 ISA 0,68
Cohen's d: 0,2 small; 0,5 middle; 0,8 large

Pearson's r sSA 0,39 ISA 0,71
Pearson's r: 0,1 small; 0,3 middle; 0,5 large

The effect size of suppression of melatonin with the small light source (sSA) can be considered as medium and with regard ro the large light source (ISA) as large. The calculated sample size for significant values of melatonin suppression with ISA is approximately 50 Persons in a group(Power: 0,8; delta:1,9; SD 3,7; alpha 0,05). The differencebetween both light sources is very small (Pearson´s r:0,005). This suggests that even with in large samples it isvery unlikely to get significant differences.

Conclusion

Optimized lighting scenarios that are embedded in the natural habitat are desirable for many reasons. For example, people suffering from dementia or shift workers may profit from an enhanced lighting system as this may help to synchronize their circadian rhythm, stabilizes sleep and brain functions, maintain health and reduce symptoms of stress. It is proven to be useful for patients suffering from seasonal affective disorders and depression. Advanced lighting technology that is embedded in the natural habitat may create a preventive working, caring and living environment, allowing individuals to conduct their daily activities without having to allocate time to light exposure interventions .

For more information and information about literature please take reference to the proceedings. Thank you.

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