SENIOR LIVING – LIGHTING, CIRCADIAN RHYTHM AND DEMENTIA I¹

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ABSTRACT

The Real Estate Fund of Pension and Disability Insurance (Nepremičninski Sklad) in Slovenia, founded in1997 is the owner of 3255 properties in 116 locations throughout the country and is intended for solving housing issues of pensioners of 65 years or older and other elderly persons who are allowed independently to live. The lease contracts are concluded for an indefinite period of time. The aim and vision of the Fund is to improve the quality of life for the elderly tenants by adapting the living environment, the flats and surroundings according to the physical needs of aging tenants.

Homes for seniors often have low light levels and poor light spectrum caused by fluorescent or incandescent lighting. Demographic changes in most European countries show rising average life expectancy which means that the number of people with weak visual capacity or visual impairment is increasing. Equally the risks of injuries due to poor lighting conditions are increasing, e.g. missing a step resulting in a hip joint fracture. Better lighting conditions are of critical importance for aging population, as stated also in the recently published CIE227:2017.

To facilitate safe environment for the elderly, the Fund in 2013 initiated a lighting research study that should provide facts and evidence for a lighting standard for their own premises. **Keywords:** elderly people, sleep problems, dementia, circadian rhythm, immune defence insomnia, blue light hazard

1. INTRODUCTION

For elderly people, one of the first signs of aging is the deterioration of visual capacity. Other signs are the weakening of muscular strength and mobility often followed by sleep problems.

This often deprives older people of healthy outdoor walks and exercise and exposure to daylight which further affects mood and wellbeing in a negative way. In addition, this also increases the risks for dementia for a growing number of older people. A disease which currently affects about 1.5 % of the population is estimated to increase to 3 % within 20 years, mainly among people older than 65 years. In Slovenia, there are around 335000 persons older than 65 years today and out of these about 5000 persons are affected by dementia. This is a heavy burden not only on the society but even more on relatives and other caregivers. Today this cost is calculated to be around 1 % of the GDP.

A lot of recent research find strong connections between disturbances of the circadian rhythm, immune defence insomnia, risks of increased development of cancers, diabetes and also dementia. It is also well known, that the circadian rhythm is depending on the ability to register the daily changes of the light and dark period via signals through the eyes.

The aging eye, which seriously limits the visual experience and perception of the environment is

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mitigating the ability to register those changes. The pupil decreases in size, the lens inside the eye becomes thicker and is less transparent for the healthy blue light and the lens scatters more light causing objects and colours to appear less vivid. Furthermore, older people begin to lose retinal neurons which not only compromises the ability to see but also to clearly register the change of light spectrum over the day which is essential to regulate the circadian rhythm or, the "body clock".

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2. ASPECTS OF LIGHTS INFLUENCE ON THE HUMAN BODY

From the beginning of the study it was decided that all aspects of lights influence on the human body should be considered, not only the IF (visual aspects) but also the NIF (nonvisual aspects).

Going through a broad spectrum of research reports it was very early understood by the team that an important key for the wellbeing of the elderly was a steady circadian rhythm. To establish this, the research reports show that the melatonin secretion should be high during evenings and nights to give a good sleep but stopped completely in the mornings to enable the production of cortisol, serotonin and other hormones essential for an alert and active life.

A great number of reports also showed that the key to this was to maintain a steady and robust daily pattern of light and dark but also the right kind of light spectrum at specific times of the day. For instance, to stop the melatonin secretion when the day starts it is important that the light spectrum should contain enough amount of blue light within the action spectra for melanopsin (455–490) nm in the so called ipRGC ganglion cells, which transmit light signals to the pineal gland where the melatonin is created. Towards the evening it was important that the light is switching out the blue action spectrum so that the melatonin secretion could start again and put the body to rest and sleep.

During the research the team also found a lot of other important effects of the NIF light and the importance of a steady circadian rhythm.

Among elderly more than 50 % suffer from chronic sleep disturbances, and poor sleep can be linked to a variety of problems like increased cardiovascular problems, disruption of endocrine functions, decline of immune functions, stability problems and poor cognition.

Several studies have shown a connection of increased risk for development of dementia and a disturbed circadian rhythm. In the studies it has been pointed out that even people already affected by dementia feel better when having a light exposure stimulating the circadian rhythm.

Since the proper lighting to stimulate a natural circadian rhythm seems to be the best medicine to avoid a number of diseases – to get the biological clock in order and at the same time stop or slow down the development of dementia, the planning of the light must be taken very seriously.

Various research projects show evidence that it is most beneficial for the elderly to use considerably higher illuminance than the standard recommendations. Large illuminated surfaces, glare free lighting and no flicker also bring important benefits.

A conclusion of the studies, which was not only about the spectrum of the day and evening light but also very much about the other aspects of light like the light distribution, luminance and glare,



Fig.1. Peak of the day spectrum curve coincides with the peak of circadian curve (dashed)



Fig.2. Night spectrum curve, however, has a valley where circadian curve (dashed) peaks

flicker and spatial reception resulted in a different kind of tender documentation which caused a lot of concerns and negative reactions among the bidders for execution. Especially the requirement of the sufficient amount of "blue light" within the action spectrum for melanopsin filtered out several of the bidding manufacturers. Only after repeating the tendering process several times did the Fund get appropriate offers at acceptable costs.

3. TECHNICAL REQUIREMENTS FOR LIGHTS AND SURFACE LIGHTING

The following is an example of the specifications of key requirements for the elderly lighting, as used in Izola pilot project:

3.1. General Information on the Tender Documents for the Scope of Lighting

Since the invention of the electrical light about 150 years ago a lot of research has been done in order to make lighting installations more energy efficient as well as to improve the visual capacity for people.

During the past ten to fifteen years, we have also seen a profound advancement in our knowledge of how light influences health and wellbeing. Due to the findings of this research, we know also about the definite correlation between different parts of the light spectrum and their effects on the body.

The spectrum of daylight changes throughout the day and affects the daily rhythm of sleep and wakefulness, what is called a circadian rhythm. Good and stable circadian rhythm improves the health and wellbeing.

For the active day and night period, the spectrum should be as much similar as possible to two attached examples. Both contain the important part of blue light and have an even spectrum for good visual performance. Important for the "healthy" effect is the light between 455 and 480 nm. For the resting/sleep period, this part should be diminished since it is suppressing the production of melatonin – "the sleep hormone". Hence, indoor light spectrum for evening's spectrum like "night spectrum" is favoured.

It is essential that the bid includes diagrams of the spectral characteristics of the selected LED light sources, since only colour temperature (CCT) and colour visibility index (CRI) are not sufficient as a source of information.

It is also very important to stress that the curves are indicatory but are showing where the different power peaks should be in the spectrum, especially for "sky lights".

Flats and common areas are designed for older people, who due to age processes have specific needs regarding the perception of light which the Contracting Authority has taken into account at defining the requirements. At the same time the elderly people are susceptible to the occurrence of glare and stroboscopic effect caused by the inadequacy of the light sources. For that reason, where possible, lights without glossy parabolic raster and lamps fitted with diffusers should be provided.

Light source has to be LED. Any differences which shall be explained and proposed by the bidder must be approved by the Contracting Authority prior to submitting the bid. This applies to all proposed deviations from these requirements. Any changes will be communicated to all bidders.

Panels must have a good quality connection to the condenser with suitably high power for cooling the LED chips.

Colour temperature is given for each of the luminous element or the specification for the dynamic lighting.

The base price for each luminous element or specification must be specified in the tender; otherwise the Contracting Authority may reject such bid as incomplete, without any possibility of the bidder's opposing this. It is recommended that the price includes the presentation of division onto housing, electronic elements and tubes (if there are any), as well as the cost of replacement components for the lighting failure. Within the individual light all the elements required for the installation and operation of the lamp at 220V should be offered. Casings and profiles shall be matt aluminium, where the housing is made of aluminium. Steel housing is powder-coated in white.

Lights must be provided with certificates: certificate of degradability, IP certificate, IK certificate, declaration of conformity of the manufacturer, the CE certificate.

Before selecting the most favourable bidder, the bidders will be required to present upon the Contracting Authority's request a sample of each type of lighting in order to approve quality and optical properties as well as luminous efficiency, distribution and glare of the lights.

For the lights such a distribution of brightness is proposed which can to a lesser extent be adjusted by the bidder with respect to its programme. The technical requirements also give indicative expected shapes of the lights. In the event that the offer includes lights with a significantly different form, the bidder is obliged to notify the Contracting Authority with an explanation as soon as possible. The Contracting Authority will on the basis of tender's judge and decide whether adjustments are acceptable. The Contracting Authority reserves the right to reject such unacceptable bid without a call for amendment or change of the bid. In order to verify the adequacy of the offered luminaires, tenderers may calculate illuminance in accordance with these instructions: Calculations should be made with a factor of maintenance 0.8 and with a high indirect light setting. As this housing project is intended for older people who are particularly sensitive to glare, glare free lighting with UGR less than 19 is mandatory.

The specified form and dimensions of the luminaires are merely illustrative – more important is the distribution of light and efficiency.

For those spectra where the C-lambda curve is noted (Melatonin suppression) the total power within this part of the spectrum as well as the power at the 460 nm peak should be given in [mW].

The colour temperature and number of MacAdam, but max 3, should be given.

"Since flicker could be causing serious health problems for a group of people like photosensitive epilepsy, migraine and impaired visual performance, the LED fixtures should in principle be flicker free. The percent flicker and flicker index metrics should be given as well as frequency, amplitudes, waveform and modulation."

Luminaires should use LED with spectral distribution which stimulates circadian rhythm, Figs.1,2.

3.2. Illumination and Lighting

For the location in Izola the successful bidder will have to supply the latest products at the time of delivery for the bid price.

Lighting levels in all the spaces are according to SIST- EN12464–1.



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