The Effect Of Light Colour During Night Time To Sleep Quality

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Abstract

Introduction: Sleep is one of the basic human needs, where human uses one third of their time only for sleeping. Some contributing factors towards bad sleep quality are stress, depression, surrounding noise, and the use of a bright light. It is known that white lights cause the activation of melanopsin, causing circadian cycle shift, whereas using yellow light does not. The aim of this research was to analyze whether there is an effect of using either white or yellow light towards sleep quality

Method: This is RCT on 81 subjects. Sleep quality was measured using PSQI questionnaire on 3 measurements with each measurement taken every week. Result of the analyzed data using the General Linear Model – Repeated Measurement (GLM-RM) method

Result: There were significant differences on PSQI score between group that used white light during sleep (7.6 ± 2.3) in comparison to the control group (5.2 ± 1.8) ($p = 0.02$), but result also showed that there were no significant difference between the group that used yellow light (6.1 ± 1.7) during sleep in comparison with the control group ($p = 0.14$). Conclusion: There is a significant difference between the uses of white lights during sleep towards sleep quality, but there has not been any significant difference between the uses of yellow light during sleep towards sleep quality

Introduction

Human have several basic needs that needs to be fullfilled in order to survive. Maslow Hierarchy of needs is one the model that shows 5 basic needs of human, including eating, drinking, reproduction, and sleep.[1] Human use one third of their life to sleep. There are several benefits that is acquired during sleep, including memory consolidation, mood stability, the resting state of the organs, and promotes body growth.[2] A good sleep quality is not only measured by its duration, but also the quality of the sleep, the sleep-wake cycles, and daytime sleep dysfunction.[3]

A study conducted in China using the CPSQI (Chinese version of the PSQI) show that the prevalence of bad sleep quality was 41.5%.[4] Another study held in SLTP "X" Kelurahan Jati, East Jakarta show that bad sleep quality among students are 62.9%.[5] These data shows that bad sleep quality is still a common thing. Some factors affecting sleep quality are stress, depression, air quality, pain, and the use of light during sleep.[6,7] The common type of lights that are used these days are white LED (Light-Emitting Diode) light, which is a combination of blue light (450 – 470 nm) and yellow phosphor (580 nm). The use of white LED light could disrupt sleep quality because retina has a specialized cells called photosensitive retinal ganglion cells (pRGCs) which contains melanopsin. Melanopsin works as a regulator of the circadian rythm, and had peak absorption around 470 – 480 nm, which could cause increased sleep onset and reduced sleep duration.[8,9] On the other hand, yellow lights do not effect the circadian rhytm because of it's peak of emission was 580 nm and does not trigger the work of melanopsin.[10]

Objective
To observe whether there is an effect between the use of white colored light and yellow colored light towards sleep quality.

Methodology
Design
This research used numerical analytic comparative study and randomized trial with control method. Statistical analysis using method of General Linear Model – Repeated Measurement (GLM-RM).

Sample
The samples that are used in this study are medical student of Universitas Pelita Harapan who fulfills the inclusion criteria of aged 18 – 21 and have a normal BMI (18.5 – 22.9), and fulfill the exclusion criteria of consuming sleeping medication, caffeine near sleep time, using eye mask during sleep, and incomplete questionnaire answers and those who did not agree to participate in the research. They are then asked to sign an informed consent.

Method of Collecting Data
Data were collected using randomized trial control. Initially, subjects are divided into 3 groups by simple random allocation method using a table random. The three groups are in comparable condition at baseline; include a control group, a group that use white light (LED 5watt), and a group that use yellow light (LED 5watt). The control group are defined as subjects that sleep in their usual or regular sleeping environment. Afterwards, subjects will be asked to fill a PSQI questionnaire as an initial score before intervention. Afterwards, subjects will be given LED lights according to their group, which would be used for 2 weeks. PSQI score will be taken after a week of intervention and 2 weeks of intervention.

Data Analysis
Data obtained were analyzed and processed using *Microsoft Excell* 2007 and *Statistical Program for Social Science* (SPSS) 24.0.

Result
A total of 81 samples were collected from the target population and the characteristic as is shown on table 1.

Table 1. **Characteristic of subjects**

Characteristic	**n(%)**
Age	
18	3 (3.7%)
19	14 (17.3%)
20	36 (44.4%)
21	28 (34.6%)
Intervention	
White light	17
Yellow light	26
Control	38

Samples were then asked to fill the first PSQI questionnaire to see the baseline scores before each designated group was given their intervention. The scores were analyzed using ANOVA and showed that there were no significant differences ($p>0.05$) between groups before intervention, with score from *levene's statistic (*$p = 0.09$). Therefore, any difference in PSQI score between groups happen due to the intervention itself.

Table 2. ***Comparation Mean Score PSQI***

	PSQI_1	**PSQI_2**	**PSQI_3**
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD**)**
White	4.8 ± 1.4	7.8 ± 2.1	7.6 ± 2.3
Yellow	5.9 ± 2.1	6.6 ± 2.3	6.1 ± 1.7
Control	5.7 ± 2.3	5.3 ± 1.9	5.2 ± 1.8

PSQI : Pittsburgh Sleep Quality Index. Good (score: ≤ 6), Bad (>6). PSQI 1: baseline; PSQI 2: a week intervention, PSQI 3: 2 weeks intervention

Table 3. ***Levene's Statistics PSQI_1(Baseline)***

PSQI_1	Levene statistic	Df1	Df2	Sig.
Based on mean	2.393	2	78	0.098
Based on median	2.117	2	78	0.127

Subjects were then given the intervention light according to their groups. PSQI score were taken after a week of intervention (PSQI 2) and 2 weeks after intervention (PSQI 3). The mean of PSQI score of each group after each week was shown in table 2.

The result showed, there are significant changes between the baseline PSQI score with the week1 score after the intervention. It could also be seen that a decline over all the group scores after 2 weeks of intervention.

Table 4. **Mean Deference a week of intervention**

Intervention group	Compared group	Mean Difference	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
White	Yellow	1.13	0.28	-0.5	2.76
	Control	2.42	0.01	0.9	3.96
Yellow	White	-1.13	0.28	-2.76	0.5
	Control	1.29	0.05	-0.03	2.63
Control	White	2.42	< 0.01	-3.96	-0.9
	Yellow	-1.29	0.05	-2.36	-0.03

PSQI score were then analyzed using ANOVA. method. Result in table 4 showed that after a week of intervention, there was significant difference between the group that used white light in comparison to the control group, therefore only the white light had effect towards sleep quality.

Table 5. **Mean difference 2 weeks of intervention**

Intervention group	Compared group	Mean Difference	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
White	Yellow	1.45	0.04	0.01	2.9
Yellow	Control	0.92	0.17	-0.25	2.11
Control	White	-2.38	<0.01	1.03	3.74

Result in table 5, showed PSQI 3 which is a significant difference between the group using white light with control group ($p < 0.01$) after 2 weeks intervention. PSQI measured between the group using white light compared to the group using yellow light ($p = 0.04$). This result showed that only white light had significant effect toward sleep quality while yellow light does not affect sleep quality to a significant level ($p=0.17$) compared with the control group. The results are then analyzed further using General Linear Model – Repeated Measurement (GLM-RM) method. This method was used to determine the effect of colored light toward sleep quality among 3 groups upon 3 measurements.

Table 6. **Accumulation of effect toward sleep quality**

Intervention group	Compared group	Mean Difference	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
White	Yellow	0.48	1	-0.76	1.73
	Control	1.31*	0.02	0.15	2.47
Yellow	Control	-0.48	1	-1.73	0.76
	White	0.83	0.14	-0.19	1.84
Control	White	-1.31*	0.02	-2.47	-0.15
	Yellow	-0.83	0.14	-1.84	0.19

Table 6. Showed that there was a significant difference between white light user with control group ($p=0.02$) while yellow color light does not have significant difference with control group ($p=0.14$). This conclude that after 3 cumulative measurements were analyzed, only white light had significant effect toward sleep quality.

Table 7. **Comparison between Groups with Control**

		Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
PSQI 1	White light	0.15	-2,11	0,33
	Yellow light	0.64	-0,81	1,32
	Control	0[a]		
PSQI 2	White light	< 0.01	1,16	3,67
	Yellow light	0.02	0,21	2,38
	Control	0[a]		
PSQI 3	White light	< 0.01	1,28	3,48
	Yellow light	0,058	-0,03	1,89
	Control	0[a]		

[a] is used as a reference

Based on the result of parameter estimates GLM-RM in table 7, it showed that before the intervention (baseline), there are no significant differences between the comparison of white and yellow lights with pvalues 0.15 and 0.64 respectively. Therefore, any changes towards the PSQI score would merely have been due to the intervention. It also showed that after one week of intervention, both groups that used white ($p < 0.01$) and yellow light ($p = 0.02$) had significant difference to the control group. But after 2 weeks of intervention, only the group that used white light had a significant difference with the control group ($p<0.01$) while the group of yellow light had no difference ($p=0.058$)

Discussion

This research was conducted in order to examine the effect of using white or yellow light towards sleep quality. In accordance with the results shown above, showed only the white colored light had significant effect towards sleep quality. Before the intervention was conducted, a baseline measurement of PSQI which was analyzed using ANOVA in order to see the homogeneity. Result showed that there was no significant difference between the three groups, therefore any changes on the PSQI score was not caused by the variety of the subjects, but merely due to the interventional methods. As shown in table 3, there were only significant difference between the group that used white light toward control group ($p = 0.022$). This was caused by the blue LED light inside the white LED light that has a wavelength of 450 – 470 nm, whereas that wavelength could stimulate the work of melanopsin which is a part of Photosensitive Retinal Ganglion Cells (pRGCs) located inside the retina[11]. The activation of melanopsin causes a signal to be send through retino-hypothalamic tract and affected suprachiasmatic nucleus (SCN) which would release glutamate and pituitary adenylate cyclase-activating polypeptide (PACAP) that would interact with NMDA and AMPA receptor that would lead to changes in the circadian cycle[11]. Contrarily, yellow LED light with a wavelength of 560 – 590 nm would not stimulate the work of melanopsin, causing minimal effect toward sleep quality. Result of this research corresponds to another research held by Seonjin Lee and Dongwook Kim which shows that sleep latency in subjects using white light was longer than those who used other colored light.[12]

Table 2 result showed a decline over the PSQI score of all group between the 1st week and 2nd week intervention. This could happen due to adaptation toward the use of light during sleep.

Conclusion

The result showed there was a significant effect of using white LED light during sleep compared to control group, whereas there was no significant effect of using yellow LED light during sleep compared to control group.

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