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INVESTIGATING THE INTENSITY OF LED DEVICES AND ASSOCIATED HEALTH IMPACT, ON COLLEGE STUDENTS IN SIDAMA REGIONAL STATE, ETHIOPIA

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ABSTRACT
Background: Light intensity significantly impacts human health, influencing vision, sleep, mood, and overall well-being. Light-Emitting Diodes (LEDs) are widely used in lighting, smartphones, tablets, and laptops due to their energy efficiency and long lifespan. However, both high and low light intensity from LED devices affects circadian rhythm, vision, and overall well-being. Despite this close relation between light intensity and human health, in- sufficient attention has been given to address the issue, particularly among college students who extensively use LED devices.
Methods: The intensity of light bulbs, laptops and mobile phones used by college stu- dents in Sidama regional state, Ethiopia was measured at different distances from the source using a portable digital Lux meter (model UNI-T UT383S, measuring range 0 to 199,900 lux). Measurements were conducted in controlled dark room environments, with data col- lected at various distances and brightness settings.
Results: The collected data demonstrated an inverse relationship between intensity and distance, consistent with the inverse square law. At near distances from the source, inten- sity exceeded recommended levels, while at far distances it fell below recommendations. At normal reading or writing positions (25cm-40cm) from laptops and mobile phones, the average intensity measured was 60 lux and 90 lux respectively, which is below the recom- mended value of 500-700 lux. Light intensity from a single bulb was also below recom- mended values for reading and writing.
Conclusion: Students are reading and writing in the evenings at light intensity below recommended values. Since intensity is closely associated with human health and work performance, the study recommends further research and awareness creation.
Keywords: LED devices, Light intensity, Health impact, Lux meter, College students, Ethiopia

1. BACKGROUND

Light is an electromagnetic radiation that has both particle and wave nature. The part of the light that is detected by human eyes covers a wavelength of 400 to 700nm (1). It plays a crucial
role in human health, influencing physical and mental well-being. We get light from natural as well as artificial sources. Natural light is essential for bone health, immune function and mood regulation. Conversely, insufficient light exposure can lead to seasonal affective disorder (SAD), depression linked to sunlight. On the other hand, exposure to artificial blue light from screens can disrupt sleep patterns by suppressing melatonin production (2).
Light intensity significantly impacts human health, influencing vision, sleep, mood, and overall well-being. High-intensity light, such as bright sunlight, can improve alertness, boost mood, and help regulate circadian rhythm by promoting melatonin suppression during the day
(2). However, excessive exposure to intense light increases the risk of eye damage, skin ag- ing, and skin cancer. Conversely, low light intensity, particularly in indoor environments can contribute to eye strain, fatigue, and disruptions in sleep patterns due to inadequate circadian stimulation (3).
International recommendations for illuminance levels for indoor artificial light without day- light (4): General office work 300-500 lx, Reading and writing 500-700 lx, Living room 100- 300 lx.
The intensity of light is measured by Lux meter. It measures the amount of light falling on a surface (lumens per square meter) with a unit Lux (lx). The fundamental SI unit of luminous intensity is the candela (cd), which measures light emitted in a specific direction.
The relationship:

$$\text{Illuminance (lx)} = \frac{\text{Luminous Intensity (cd)}}{\text{Distance}^2\ (\text{m}^2)} \quad (1)$$

The intensity of light is inversely proportional to the square of the distance from the source. The intensity of light decreases as the distance from the light source increases. This follows the inverse square law.
Mathematically:

Where:

$$I = \frac{4\pi d^2}{P} \quad (2)$$

- I = Light intensity (lux or lumens per square meter)
- P = Power of the light source (lumens)
- d = distance from the light source (meter)

Both high as well as low light intensity affects circadian rhythm, vision, and overall well- being. These show a close relation between the intensity of light and human health but not enough attention is given to address the issue. Therefore, this study focuses on the investigation of light intensity of LED devices, such as LED bulbs, smart phones and Laptops, which are commonly used by College students in Sidama region, Ethiopia.

LED (Light-Emitting Diode) is a forward-biased unidirectional semiconductor device that allows electric current to pass. LEDs are used in lighting, smartphones, tablets, and TV screens due to their energy efficiency, long lifespan, instant illumination, and compact size (5). The intensity of LED light can significantly impact human health, particularly in terms of vision, sleep, and overall wellbeing. LEDs especially those emitting high levels of blue light, can suppress melatonin production, disrupting sleep patterns and leading to insomnia or poor sleep quality. Prolonged exposure to intense LED lighting, such as in workplaces or digital screens, can contribute to eye strain.

On the other hand well-regulated LED lighting can enhance alertness, mood, and produc- tivity, particularly in environments with controlled brightness and colour temperature.

However, excessive exposure to high-intensity LED lights at night has been linked to an increased risk of circadian rhythm disorders, metabolic issues, and even cardiovascular prob- lems (6). To mitigate these problems experts recommend using warmer, dimmable LEDs in the evening and reducing screen exposure before bedtime.

2. MATERIALS AND METHODS

2.1 Measuring the intensity of LED devices

For measuring the intensity of visible light released from different LED light sources, Lux meter (digital light meter) is used. In this particular measurement Lux meter with model UNI-T UT383S, measuring range 0 to 199,900 lux, accuracy 4% for natural light and 5% for artificial light and resolution (0.1-1) lux was implemented to measure the intensity of LED bulbs, Laptops and smartphones.

Figure 1: Lux meter

2.1.1 Measuring the intensity of LED bulbs

The measurement was performed inside a dark room in the evening. Suspending a bulb from the centre of a large class room ceiling, which is painted black for this purpose, is used to reduce reflection from any direction. A meter stick was used to measure the vertical distance from the centre tip of the bulb to the lux meter photo-detector. The sensor was positioned at 10cm from the bulb and adjusted to face the bulb. The intensity of the light bulb was measured three times in each distance and the average value was recorded. By repeating the same procedure at different distances from 3W, 9W, 12W and 18W bulbs, the data was collected.

2.1.2 Measuring the light Intensity of Laptops and mobile phones

Sample LED Laptops and smart mobile phones that are used by most of the college students were collected from voluntary students during their free time. The measurement was conducted in physics optics laboratory, at Hawassa College of Teacher Education, in the afternoon from 4:00 to 6:00 local time, for one week. A ruler, large table, 3 Laptops and 5 mobile phones, and Lux meter were the materials used to conduct the measurement.

A large table (1m x 2m x 4m) was placed at the centre of dark room and the intensity of each LED device was measured at different distances by considering possible background effect.

3. RESULTS AND DISCUSSION

The intensity of LED devices commonly used by college students was measured using Lux meter and the results are

presented in the figures below. The data obtained in all cases show the inverse relationship between intensity of light and the distance from the light source, which agrees with the inverse square law (1). On the other hand the intensity of LED light at close distance from the source of light is more than recommended values but as the distance from the source of light increases the intensity decreases to below recommendations. Lighting sources have an impact on our health and wellbeing, and artificial light needs to be more similar to daylight. Each room has to have proper level of light intensity according to its functions, which is dependent on the type and number of light bulbs.

3.1 Intensity of light bulbs

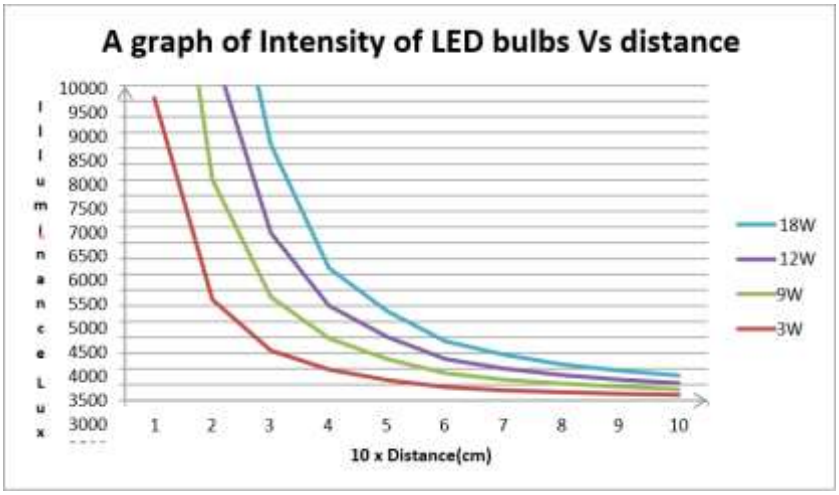

Figure 2: A graph of Intensity of the light bulbs versus distance

Figure 2 shows the relation between the intensity of light bulbs with distance. Apart from their difference in power consumption, all the light bulbs have the same brand and were connected to the same power source during the intensity measurement. The data shows direct relation between the intensity and power consumption and inverse relation with distance. From all the light bulbs the intensity was higher than the recommended value at short distances and lower at far distances (7).

The intensity of light in a room depends on both the power of the bulb and the size of the room. The data demonstrate that a higher wattage bulb generally emits more luminous flux, resulting in greater light intensity. However, this intensity is also affected by the room size; in a larger room, the same amount of light is distributed over a large area, reducing its intensity per unit area. Therefore, for adequate illumination, more powerful bulbs or additional light sources are needed in bigger rooms. Conversely, a small room may require only a low-power bulb to achieve sufficient brightness. In general, not only high intensity but also low intensity of light can affect human health. For a healthy lifestyle the type of light source, the distance from the light source, and the direction of the light source should be taken into consideration.

3.2 Intensity of laptops and Mobiles

3.2.1 Intensity of Laptops

The intensity of the three Laptops (HP Spectre x360, Lenovo ThinkPad x1 Yoga and Dell XPS, all have 15.6” HD LED Display) measured at different distances horizontally from the centre of the screen when their brightness is adjusted at 50% and the same text page displayed on the screen is presented below.

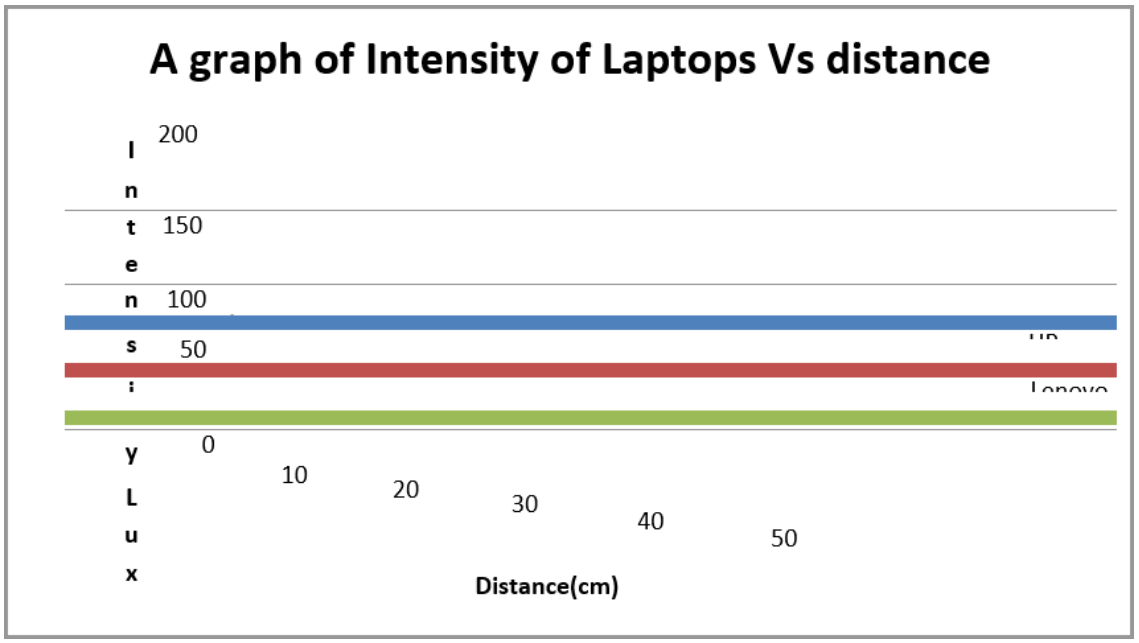

Figure 3: A bar chart of Intensity of Laptops at variety of distances

The three laptops have the same screen size, 50% brightness and similar text page displayed during the measurement and Figure 3 shows how the intensity of laptops decreases with dis- tance. At the same distance from the laptops the intensity obtained was nearly the same, since the total light output depends on screen area and luminance. Small difference in intensity within laptops is due to variations in backlight power and display calibration.

3.2.2 Intensity of HP laptop

The intensity of HP laptop measured at different distances horizontally from the centre of the screen when the brightness was adjusted at 25%, 50% and 100% while the screen displays the same text page is depicted below.

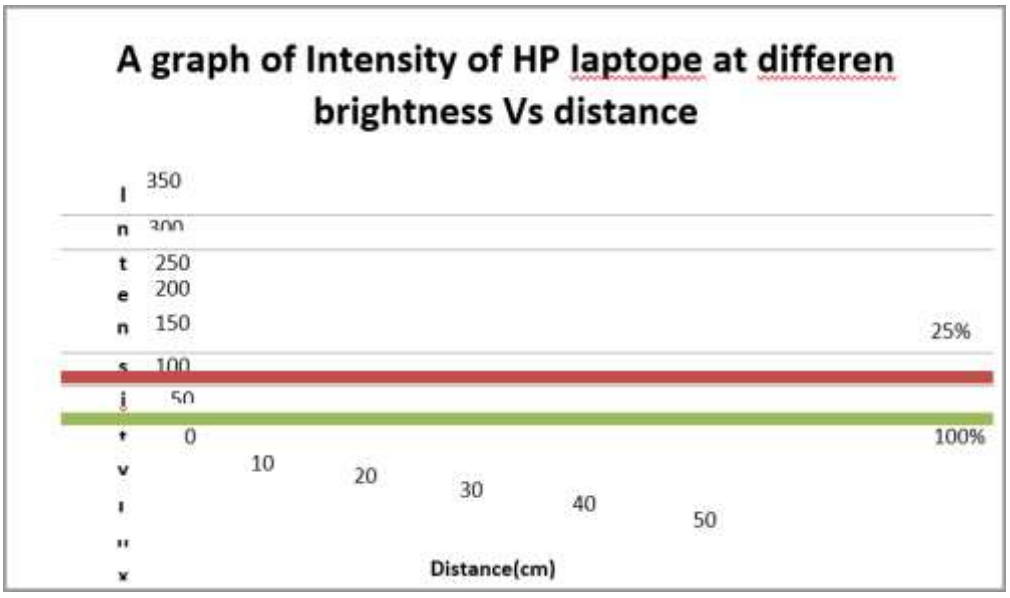

Figure 4: A bar graph of Intensity of HP laptop with different brightness against distance The data in Figure 4 demonstrate the direct dependence of the intensity of light on the brightness adjustment and at short distances from the laptop the dependence is more noticeable. Working on a laptop without any background or ambient light can strain eyes and negatively affect vision over time. The high contrast between the bright laptop screen, and the surrounding darkness forces eyes to constantly adjust, leading to eye fatigue, dryness, and discomfort. It may also disrupt sleep cycle, especially if exposed to blue light from the screen at night, as it can interfere with melatonin production. In order to reduce these effects, it is recommended to keep a soft background light on while using a laptop in a dark room.

3.2.3 Intensity of mobile phones

The intensity of the five cell phones (Samsung Galaxy A52, Techno Spark, Infinix Hot 8, Sony Xperia 1 V and Nokia C20, all have 6.5" LED Display) measured at different distances hori- zontally from the centre of the screen when their brightness is adjusted at 50% and the same text page displayed on the screen is presented below.

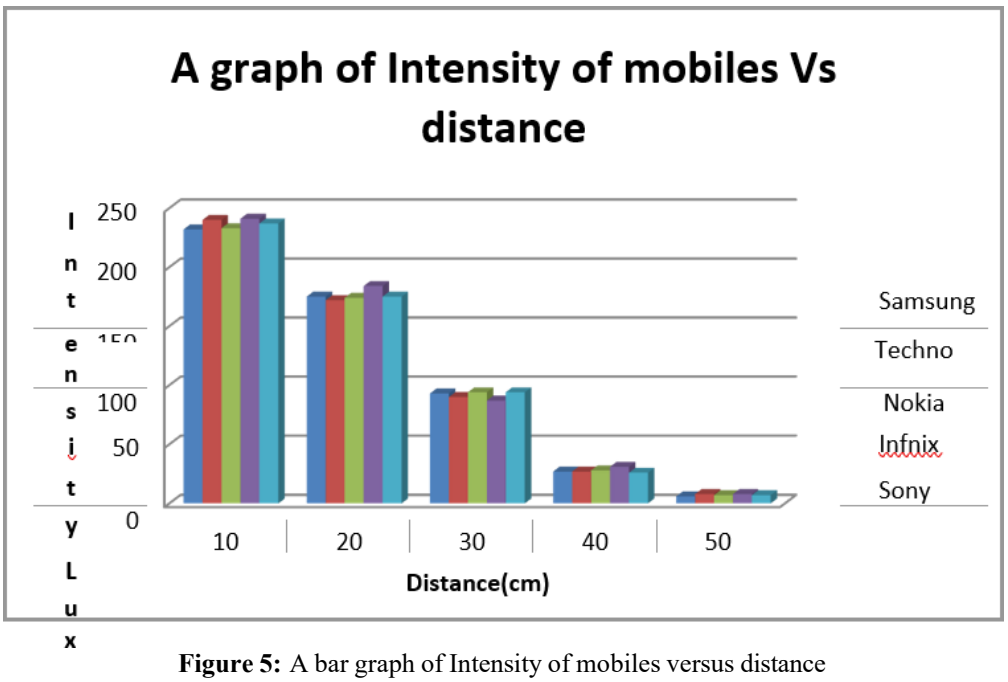

Figure 5: A bar graph of Intensity of mobiles versus distance

3.2.4 Intensity of Samsung mobile

The intensity of Samsung mobile measured at different distances horizontally from the centre of the screen when the brightness was adjusted at 25%, 50% and 100% while the screen displays the same text page is depicted below.

The data reflects the intensity of mobile phone dependency on brightness adjustment and how modern users increasingly rely on screen brightness settings to optimize their viewing ex- perience and device usability. Mobile phones are used in a wide range of lighting environments making brightness adjustment essential for visibility and eye comfort.

Users often depend on automatic brightness features, which use ambient light sensors to dynamically adjust screen intensity based on surroundings. This dependency is not just about comfort; it also impacts battery life, with higher brightness levels consuming more power.

Additionally, excessive brightness in low-light settings can cause eye strain or disrupt sleep patterns, leading users to adjust intensity frequently or rely on features like night mode. Smart phones become more integral to daily life, managing screen brightness becomes a critical aspect of user interaction and overall device performance.

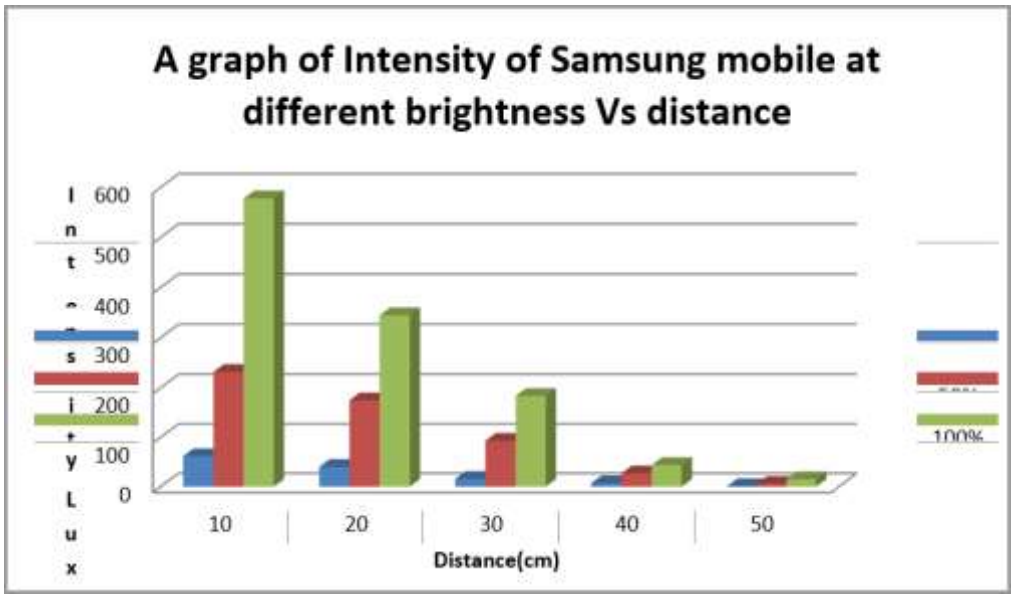

Figure 6: A bar graph of Intensity of Samsung mobile versus distance

The data in Figure 6 show how the intensity of light from the cell phone varies with distance and brightness adjustments. The intensity of the mobile is directly related with the brightness.

In general the intensity obtained from laptops and mobile phones depend on the distance from the sources and the adjustment of the brightness. The light intensity has direct relation with the brightness of the devices. For comfortable vision the brightness has to be adjusted moderately and there should be enough background light. At average distance from mobile phone and laptops the intensity obtained was below the recommended value for reading or writing without background light source (4).

Both high as well as low intensity of LED light can have significant effects on human health, influencing sleep patterns, eye strain, and overall well-being. Exposure to high-intensity LED light, in the evening can suppress melatonin production, disrupting circadian rhythms and lead- ing to sleep disturbances (2). Prolonged exposure to bright LEDs can also cause digital eye strain, characterized by dry eyes, headaches, and visual discomfort (3).

Low light intensity can have various negative effects on human health, particularly con- cerning vision, mood, and cognitive function. Inadequate lighting can cause eye strain and discomfort due to increased effort in focusing, leading to headaches and reduced visual clarity

(5). Low light environments have also been linked to seasonal affective disorder (SAD) and depressive symptoms, as insufficient natural or artificial light exposure can reduce serotonin levels and disrupt circadian rhythms (8).

On the other hand appropriate LED lighting can improve alertness and mood during the day, particularly in workplaces and educational settings. Thus managing LED light intensity is sig- nificant for healthy life and good performance in humans. The study shows students are reading and writing in the evenings at light intensity that is below recommended value. Since intensity is closely associated with human health and work performance, the study recommends further research and awareness creation regarding proper lighting conditions for academic activities.

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Conflict of Interest

The authors declare no conflict of interest.

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Table 1: The luminous intensity of LED bulbs measured at different distances

Distance (cm)	**3W**	**9W**	**12W**	**18W**
10	9600	9900	11000	12000
20	3200	3800	4200	5300
30	1580	1700	2040	2800
40	980	990	1030	1200

50	640	670	700	820
60	420	440	450	560

Table 2: The Intensity of Laptops at different distance from the screen

Distance (cm)	**HP**	**Lenovo**	**Dell**
10	198	194	194
20	124	130	128
30	67	69	66
40	19	21	19
50	6	5	6

Table 3: Intensity of HP laptop with different brightness against distance

Distance (cm)	**25%**	**50%**	**100%**
10	74	198	324
20	38	124	197
30	12	67	75
40	7	19	23
50	1	6	7

Table 4: The Intensity of mobile phones at different distances from the screen

Distance (cm)	**Samsung**	**Techno**	**Nokia**	**Infinix**	**Sony**
10	232	240	233	241	237
20	175	172	174	184	175
30	93	90	94	87	94
40	27	27	28	31	26
50	6	8	7	8	7

Table 5: Intensity of Samsung mobile with different brightness at different distances

Distance (cm)	**25%**	**50%**	**100%**
10	62	232	578
20	40	175	345
30	16	93	184
40	7	27	44
50	1	6	15