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ENERGY SAVINGS AND HUMAN PERFORMANCE, TRANSITION TOWARDS EFFICIENT LIGHTING IN COMMERCIAL BUILDINGS

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ABSTRACT

Purpose: Evaluate human performance under LED lighting system in commercial building regarding:-Visual Performance (VP), Motor Performance (MP), Task Performance (TP), Cognitive Performance, Human Performance, and Work Life. To assess the direct effect between Cognitive Performance and Human Performance To identify the role of Circadian System (M1), and Discomfort (M2) between Cognitive Performance and Human performance.

Theoretical framework: Driven lighting is presently the most reliable. As a result, determining all crops' light needs is complicated. Purposive sampling use to select the respondents. Floor office units and single office rooms required LED illumination. Because the entire population list was unavailable, 200 samples chose for the investigation. The study looked at an employee's cognitive and human performance. No relation between visual and cognitive performance. Pain impairs cognitive and motor functions. No discomfort affects work-life balance. However, the pain reduces human performance. Distress, eye pain, and weariness impede human performance. However, visual discomfort, visual message, glare, and flicker do. The study recommends assessing visual performance based on employee illumination discomfort.

Design/Methodology/Approach:Driven lighting systems are now the most widely used and dependable in the world. Compact fluorescent light bulbs are used in India's current lighting systems for the most part. Even though there are a few small and medium-sized LED producers, there is no industry standard for LED production. As a result, estimating the amount of light all types of produce require is difficult. The goal of this research was to find out how LED illumination affects human performance. An organized questionnaire was utilized to gather information from employees of various government and commercial sector organizations. The research focused on the Trivandrum area because Trivandrum is Kerala's capital and home to most of the state's administrative offices. Respondents were drawn from government and private sector offices using a stratified random sampling approach. Offices were divided into floor office units and single office rooms, with LED lighting systems required in all of them. Two hundred samples were chosen for the study after the reliability and genuineness of obtained data were checked because the entire population list was unavailable.

Findings: Research, Practical & Social Implications: As a result of this research, we set out to determine how well LED and conventional (linear fluorescent, compact fluorescent, and incandescent) lighting systems perform luminously, how well people perform, and how much they cost in the most common luminaire applications currently found in the environment. The popularity of LED lighting systems has overtaken that of all other kinds of fabricated luminaires. In contrast, linear and compact fluorescent luminaires are used in most Indian lighting systems now in use. No LED standards exist, despite just a handful of medium and small firms currently producing LED lights. As a result, establishing the precise illumination requirements

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for each product is challenging to do. Compare the environmental, technological, and economic factors to the alternatives now accessible to discover a better solution.

Originality/value: Human performance is very much important in every sector and it's depended on various multi-dimensional factors. Here the study has been analysed the direct and indirect effect between Cognitive Performance and Human performance of an employee. Simultaneously, study is saying that cognitive performance is not depending on the visual, and task performance. On the other hand, it could be seen that, Cognitive performance is affected by discomfort and the motor performance influence towards the Cognitive performance is positive but not significant. In the case of work life, it has no influence towards the human performance and also discomfort is influencing the human performance. While analyzing the mediation effect, it was found that, direct effect of Cognitive Performance will increase the Human Performance, but the existence of discomfort will reduce the human performance. Which means that negative mood change, visual discomfort, discomfort to visual message, Glare, Flicker, Eye pain, and fatigue are reducing the human performance. Based on the findings from the study, it could be seen that visual, motor and task performance is not influencing the cognitive performance, at the same time visual discomfort, discomfort to visual message, Glare, Flicker are decreasing their performance. hence, the study is suggesting that visual performance should be measure on the basis of various discomforts faced by the employee from their work place lightening.

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ECONOMIA DE ENERGIA E DESEMPENHO HUMANO, TRANSIÇÃO PARA ILUMINAÇÃO EFICIENTE EM EDIFÍCIOS COMERCIAIS

RESUMO

Objetivo: Avaliar o desempenho humano sob o sistema de iluminação LED em edifícios comerciais em relação a: Desempenho Visual (VP), Desempenho Motor (MP), Desempenho de Tarefas (TP), Desempenho Cognitivo, Desempenho Humano, e Vida Profissional. Avaliar o efeito direto entre Desempenho Cognitivo e Desempenho Humano Identificar o papel do Sistema Circadiano (M1), e Desconforto (M2) entre Desempenho Cognitivo e Desempenho Humano.

Estrutura teórica: A iluminação dirigida é atualmente a mais confiável. Como resultado, determinar todas as culturas' as necessidades de luz são complicadas. Uso de amostragem proposital para selecionar os respondentes. Unidades de escritório de piso e salas de escritório individuais requerem iluminação LED. Como a lista completa da população não estava disponível, 200 amostras foram escolhidas para a investigação. O estudo examinou um funcionário's desempenho cognitivo e humano. Nenhuma relação entre o desempenho visual e cognitivo. A dor prejudica as funções cognitivas e motoras. Nenhum desconforto afeta o equilíbrio trabalho-vida. Entretanto, a dor reduz o desempenho humano. A angústia, a dor nos olhos e o cansaço impedem o desempenho humano. Entretanto, o desconforto visual, a mensagem visual, o ofuscamento e a cintilação afetam. O estudo recomenda avaliar o desempenho visual com base no desconforto da iluminação do funcionário.

Design/Metodologia/Proteção: Os sistemas de iluminação dirigida são agora os mais utilizados e confiáveis do mundo. As lâmpadas fluorescentes compactas são usadas na Índia's sistemas de iluminação atuais para a maior parte. Embora existam alguns pequenos e médios produtores de LED, não há nenhum padrão industrial para a produção de LED. Como resultado, estimar a quantidade de luz que todos os tipos de produtos requerem é difícil. O objetivo desta pesquisa foi descobrir como a iluminação LED afeta o desempenho humano. Um questionário organizado foi utilizado para coletar informações de funcionários de várias organizações governamentais e do setor comercial. A pesquisa se concentrou na área de Trivandrum porque Trivandrum é a capital de Kerala's e o lar da maioria dos escritórios administrativos do estado's. Os entrevistados foram oriundos de escritórios do governo e do setor privado usando uma abordagem de amostragem aleatória estratificada. Os escritórios foram divididos em escritórios de piso e salas de escritório individuais, com sistemas de iluminação LED necessários em todos eles. Duzentas amostras foram escolhidas para o estudo depois que a confiabilidade e genuinidade dos dados obtidos foram verificadas, pois a lista completa da população não estava disponível.

Conclusões: Pesquisa, Implicações Práticas e Sociais: Como resultado desta pesquisa, nos propusemos a determinar o desempenho luminoso dos sistemas de iluminação LED e convencionais (fluorescente linear, fluorescente compacta e incandescente), o desempenho das pessoas e o custo nas aplicações mais comuns de luminárias atualmente encontradas no ambiente. A popularidade dos sistemas de iluminação LED ultrapassou a de todos os outros tipos de luminárias fabricadas. Em contraste, as luminárias fluorescentes lineares e compactas são utilizadas na maioria dos sistemas de iluminação indianos atualmente em uso. Não existem padrões LED, apesar de apenas um punhado de empresas de médio e pequeno porte que atualmente produzem luzes LED. Como resultado, estabelecer os requisitos precisos de iluminação para cada produto é um desafio. Compare os fatores ambientais, tecnológicos e econômicos com as alternativas agora acessíveis para descobrir uma solução melhor.

Originalidade/valor: O desempenho humano é muito importante em todos os setores e depende de vários fatores multidimensionais. Aqui o estudo foi analisado o efeito direto e indireto entre o desempenho cognitivo e o desempenho humano de um funcionário. Simultaneamente, o estudo está dizendo que o desempenho cognitivo não depende do desempenho visual e do desempenho da tarefa. Por outro lado, pode-se ver que o desempenho cognitivo é afetado pelo desconforto e que a influência do desempenho motor em relação ao desempenho cognitivo é positiva, mas não significativa. No caso da vida profissional, ela não tem influência sobre o desempenho humano e também o desconforto está influenciando o desempenho humano. Ao analisar o efeito de mediação, descobriu-se que, o efeito direto do desempenho cognitivo aumentará o desempenho humano, mas a existência de desconforto reduzirá o desempenho humano. O que significa que mudanças de humor negativas, desconforto visual, desconforto à mensagem visual, brilho, cintilação, dor ocular e fadiga estão reduzindo o desempenho humano. Com base nos resultados do estudo, pode-se ver que o desempenho visual, motor e de tarefa não está influenciando o desempenho cognitivo, ao mesmo tempo, o desconforto visual, o incômodo à mensagem visual, o Glare, Flicker estão diminuindo seu desempenho.

Palavras-chave: Iluminação LED, Desempenho Cognitivo, Equilíbrio entre Trabalho, Vida Pessoal.

AHORRO DE ENERGÍA Y RENDIMIENTO HUMANO, TRANSICIÓN HACIA UNA ILUMINACIÓN EFICIENTE EN LOS EDIFICIOS COMERCIALES

RESUMEN

Objetivo: Evaluar el rendimiento humano bajo un sistema de iluminación LED en un edificio comercial en relación con: el rendimiento visual (VP), el rendimiento motor (MP), el rendimiento de la tarea (TP), el rendimiento cognitivo, el rendimiento humano y la vida laboral. Evaluar el efecto directo entre el Rendimiento Cognitivo y el Rendimiento Humano Identificar el papel del Sistema Circadiano (M1), y el Malestar (M2) entre el Rendimiento Cognitivo y el Rendimiento Humano.

Marco teórico: La iluminación dirigida es actualmente la más fiable. Como resultado, la determinación de todos los cultivos' necesidades de luz es complicada. Se utiliza un muestreo intencionado para seleccionar a los encuestados. Las unidades de oficina de la planta y las salas de oficina individuales requerían iluminación LED. Como no se disponía de la lista de toda la población, se eligieron 200 muestras para la investigación. El estudio analizó el rendimiento cognitivo y humano de los empleados. No hay relación entre el rendimiento visual y el cognitivo. El dolor perjudica las funciones cognitivas y motoras. Las molestias no afectan al equilibrio entre el trabajo y la vida privada. Sin embargo, el dolor reduce el rendimiento humano. La angustia, el dolor ocular y el cansancio impiden el rendimiento humano. Sin embargo, la incomodidad visual, el mensaje visual, el deslumbramiento y el parpadeo sí lo hacen. El estudio recomienda evaluar el rendimiento visual en función de la incomodidad lumínica de los empleados.

Diseño/Metodología/Enfoque: Los sistemas de iluminación dirigidos son actualmente los más utilizados y fiables del mundo. Las bombillas fluorescentes compactas se utilizan en su mayor parte en los sistemas de iluminación actuales de la India. Aunque hay algunos productores de LED pequeños y medianos, no existe una norma industrial para la producción de LED. Por ello, resulta difícil estimar la cantidad de luz que necesitan todos los tipos de productos. El objetivo de esta investigación era averiguar cómo afecta la iluminación LED al rendimiento humano. Se utilizó un cuestionario organizado para recopilar información de los empleados de varias organizaciones del sector gubernamental y comercial. La investigación se centró en la zona de Trivandrum porque ésta es la capital de Kerala y alberga la mayoría de las oficinas administrativas del estado. Los encuestados se extrajeron de las oficinas del gobierno y del sector privado mediante un enfoque de muestreo aleatorio estratificado. Las oficinas se dividieron en unidades de oficina de planta y salas de oficina individuales, y en todas ellas se exigieron sistemas de iluminación LED. Se eligieron doscientas muestras para el estudio tras comprobar la fiabilidad y autenticidad de los datos obtenidos, ya que no se disponía de la lista completa de la población.

Conclusiones: Investigación, implicaciones prácticas y sociales: Como resultado de esta investigación, nos propusimos determinar el rendimiento lumínico de los sistemas de iluminación LED y convencionales (fluorescentes lineales, fluorescentes compactos e incandescentes), el rendimiento de las personas y su coste en las aplicaciones de luminarias más comunes que se encuentran actualmente en el entorno. La popularidad de los sistemas de iluminación LED ha superado a la de todos los demás tipos de luminarias fabricadas. En cambio, las luminarias lineales y fluorescentes compactas se utilizan en la mayoría de los sistemas de iluminación de la India que se utilizan actualmente. No existen normas sobre LED, a pesar de que sólo un puñado de empresas medianas y pequeñas producen actualmente luminarias LED. Por ello, establecer los requisitos precisos de iluminación para cada producto es todo un reto. Hay que comparar los factores medioambientales, tecnológicos y económicos con las alternativas ahora accesibles para descubrir una solución mejor.

Originalidad/valor: El rendimiento humano es muy importante en todos los sectores y depende de varios factores multidimensionales. En este estudio se ha analizado el efecto directo e indirecto entre el rendimiento cognitivo y el rendimiento humano de un empleado. Al mismo tiempo, el estudio dice que el rendimiento cognitivo no depende del rendimiento visual y de la tarea. Por otro lado, se observa que el rendimiento cognitivo se ve afectado por la incomodidad y que la influencia del rendimiento motor en el rendimiento cognitivo es positiva pero no significativa. En el caso de la vida laboral, no tiene influencia hacia el rendimiento humano y también la incomodidad está influyendo en el rendimiento humano. Al analizar el efecto de mediación, se encontró que, el efecto directo del rendimiento cognitivo aumentará el rendimiento humano, pero la existencia del malestar reducirá el rendimiento humano. Esto significa que el cambio de humor negativo, la incomodidad visual, la incomodidad del mensaje visual, el deslumbramiento, el parpadeo, el dolor de ojos y la fatiga reducen el rendimiento humano. Basándose en los resultados del estudio, se puede observar que el rendimiento visual, motor y de la tarea no influye en el rendimiento cognitivo, mientras que el malestar visual, la incomodidad del mensaje visual, el deslumbramiento y el parpadeo disminuyen el rendimiento.

Palabras-clave: Iluminación LED, Rendimiento cognitivo, Equilibrio entre vida, Trabajo.

INTRODUCTION

An essential player in the global energy industry will be China, with over 1.5 billion people and one of the world's fastest-expanding economies in recent years. India's government has made significant progress in providing its citizens with access to electricity and raising the quality of cooking facilities. As a result of these reforms, it now produces a considerable quantity of renewable power from sources like solar.

Global energy consumption grew slower in 2019 than the 2% average growth rate between 2000 and 2018, as the economy grew more slowly. China (+3.2 percent), the world's top user since 2009, Russia (+1.8 percent), and India (+0.8 percent) all had slower increases in energy consumption than in prior years. Most OECD countries, including the United States (-1%), the EU (-1.9%), Japan (-1.6%), Canada, and South Korea, are dissatisfied with their national health care systems. The only country to defy the trend was Australia, which had its population rise by 6.3% due to increased gas consumption from LNG facilities. Despite slight increases in consumption in Indonesia and Algeria, Saudi Arabia, Nigeria, and South Africa, consumption increases. At the same time, Latin America saw a decline (stable in Brazil and a slight decrease in Mexico). Venezuela and Iran's consumption fell as a result of US sanctions.(IEA, 2020).

People used to get their energy from the sun and fire. This historical period's basic lighting principles came from the necessity for people's eyes to see well in dim light. The presence of light is a necessary and common occurrence in our universe. We are less dependent on sunshine, moonlight, and candle and fire illumination at night now that we have a wide range of electric light sources.(Paul, 2004).

Artificial lighting has gone through three phases since incandescent lights in 1882, including incandescent lamps, neon lights, and discharge lamps. It is now moving into the fourth phase, which includes semiconductor lighting, mainly white LEDs. Since then, there have been three phases of artificial lighting. Since white LEDs are already being utilized in a wide range of products, they will soon be available to a far wider audience. There is much economic potential for white light-emitting diodes (LEDs), as they are projected to be the primary lighting source in the 21st century.(Gee, 2004). As new light sources hit the market, the lighting sector is seeing a shift. As a result of LEDs, designers have new options for modifying the color and usage of light in their products.(Chen, 2010).There is a growing number of lighting equipment producers, evidence of the foundations of lighting's long-term strength. For good illumination distribution in space, they will have appropriate spectral characteristics, no glare, and be reasonably priced. The development and implementation of

new lighting technologies fulfil societal expectations. The efficiency of the illumination can vary widely based on a wide range of factors. It is heavily influenced by what people want and have experienced with electric illumination.(Dubois, 2011).

There have been several methods proposed for determining illumination quality.(Bear, 1992). There is a 50/50 split between scientific and psychological data in the design of the lighting.(Veitch, 2001). Even if have much light, the lighting quality might vary widely. Luminance distributions, light color properties, and illumination uniformity are all aspects of lighting quality.(Veitch J. A., 1998). The way we perceive light influence by a wide range of physiological and physical variables. Traditional photometric approaches cannot correctly assess lighting quality, and there is no universally applied metric for excellent lighting.(Boyce, 2003).

The type, amount, and quality of light emitted around us affect how we perceive our environment. Understanding the relationship between color, light, and vision is critical for our well-being. Lighting systems have remarkable longevity because they enable humans to do physical or visual activities effectively. The efficiency with which they do so is proportional to the setting's quantity and quality. When it comes to lighting, keep in mind how it will affect the inhabitants' well-being. Space lighting installation quality in terms of energy use, aesthetics, and functionality are all critical factors to consider. However, the importance of energy conservation has grown due to the growing cost of energy and the growing need to battle climate change. As a result, more energy-efficient lighting saves money and is intimately linked to the electronic devices that operate it.

REVIEW OF LITERATURE

This research examines the country's development in energy production for the first time in-depth, looking at the accomplishments and problems it has faced. India is an excellent example for other nations since it has done a fantastic job increasing access to energy and clean cooking for its citizens.

The ability to see well is one of the most important senses. A light that stimulates the part of the electromagnetic spectrum linked with vision requires our ability to see. The light must be present in sufficient quantities and transmitted appropriately to provide the best possible visual experience. Light has several non-visual impacts outside the ones we can see. Researchers have learned more and more about how light affects human health and well-being since identifying the third kind of photoreceptor in the human eye—the impact of light on the circadian clock.

On the other hand, artificial lighting is a significant energy user in an office building. In the previous few decades, efforts have been made to minimize energy use and build a better energy future. It is possible to compare the efficiency of various light sources using current technological advancements. The fluorescent lamp utilizes an electric discharge to generate light. Fluorescent materials produce UV radiation, which ionizes mercury atoms, the primary light source. A long tube with electrodes at either end holds mercury vapor, used to ignite a small amount of gas. Nearly majority of the UV light is released in the UV zone, where emission peaks occur at 254 nm and 185 nm. A phosphor coating in the tube transforms UV energy into light, illuminating the area. When one UV photon is absorbed, and only one visible photon is generated, more than 65 percent of the initial photon energy is lost as heat. As a result, the output light spectrum changes based on the phosphor combinations.

Temperatures in the lab can be as high as 7500K (a cool blue) or as low as 2700K (daylight). Color rendering indices range from 50 to 95. The new fluorescent lighting produces roughly 100 lumens of light for every watt (without ballast losses). Specific high-voltage circuit designs are necessary for dimming to 1 percent. There are two electrodes on either end of a mercury-vapor discharge tube, which gives linear fluorescent light sources their name. When the electrodes on the tube are heated, electrons are released, resulting in a current being generated. The inner bulb wall's phosphor coating converts the mercury arc's UV energy into visible light. Linear fluorescent bulbs provide omnidirectional light that disperses in all directions.

The circadian system responds to light and can alter human performance. The sleep/wake cycle frequency is the most evident sign that humans have a circadian rhythm. In the background, a variety of hormonal cycles are in play. The body's circadian system is influenced by lighting conditions, notably the light-dark cycle, which can affect the performance of all tasks, not only visual ones. Lighting has changed in recent years as a result of technological advancements that aim to improve efficiency. There are two outcomes to consider: Bright light disrupts the circadian rhythm by day and suppresses the production of the melatonin hormone by the body at night.(Crowley, 2003). When used correctly, both of these impacts can enhance a person's ability to perform. People who work day jobs have been trying unsuccessfully to make the transition to night occupations. The problem is that the change has to be implemented throughout one day rather than just during working hours.(Bøggild, 1999). Bright light exposure before night enhances performance on cognitively demanding activities, at least in the short term. (Keis, 2014).

Perception has a role in how successful a person is. After the brain has processed the visual picture, perception takes control. An unpleasant lighting condition is one in which the visual output is complex to a great degree. When flicker and glare are present in the illumination, they might cause interference with the work.(Rodriguez, 2016). Perception is much more than a hazy uneasiness. Lighting design, purchase, and maintenance all reveal something about the people in charge. The message interprets by the environment's meaning and the speaker's values based on the installation. The message's importance outweighs the inconvenience, making the trip to the dancing club worthwhile. In response to the message, people's feelings and actions might influence.(Montgomery, 2004).

The visual output changes according to the job's complexity, the degree of contrast in the information, and the lighting conditions. There is a compressive function to the visual output form over a wide range of sizes, contrasts, and retinal illuminances of retinal images.(Tan, 2010). There is no change in performance, but performance significantly degrades when any of these variables falls below a certain threshold. This form keeps track of when the visual output is being evaluated. The questionnaire was designed with the notion of technology and human efficiency in mind while also considering numerous aspects that contributed to the success. The speed and accuracy with which a visual task may be completed are known as visual performance. Visual performance models are used to investigate the connections between visual tasks, observer age, and brightness levels to find out how they interact.(Hamedani, 2020). When light levels are optimized, a visual output that exceeds the society's visibility thresholds is guaranteed. The best visual efficiency is achieved when the light source is set to a medium degree of intensity. At high luminance levels, a ceiling effect prevents additional increases in luminance from causing alterations.(Osterhaus, 1992). Electricity usage for illumination should be kept under check to improve energy efficiency while maintaining the most excellent possible lighting quality. A comfortable and efficient visual and luminous environment can only be built after ensuring enough illumination at a minimum. That low illumination is terrible for people's health and eyesight. It can lead to visual discomfort is acknowledged by the policy. However, good lighting that does not cause undue strain on the eyes is preferable but not necessary. For this reason, insufficient illumination may provide subpar illumination, while an excess of illumination may result in overexposed illumination.(Ige, 2016).

There is no uniform approach to developing aesthetically pleasing luminous settings while working on lighting design.(Boyce, 2003)(Veitch J. A., 2001). Illuminance values for various activities are recommended in the current lighting guidelines, including a wide range of values. There is also a discussion on lighting techniques in a room, glare restrictions, and the

many light hues that exist. This room's level of shadow and reflection must be considered. In terms of lighting design, the focus is on removing visual pain; however, designers may also consider visual comfort while creating lighting schemes. Too little light, too much light, too much luminous coverage, too uniform lighting, annoying glare, distracting reflections, too strong shadows, and flicker from light sources can all cause visual discomfort.(Boyce P. R., 2010).

The room's spectral power distribution determines the hue of the room's surfaces. Light output is evaluated using the CCT and CRI indices. On a color spectrum, the color temperature of light determines how colourful it appears (CCT). To determine a light source's CRI, an expert compares it to a common light source that produces the same set of test colors but at a different temperature. (Rea, 2008). CIE employs Luminance, Hue, and Chroma in addition to the eight primary colors. The more spectacular light is, the higher the CRI is, and the maximum value is (100). There are issues with the CIE. LEDs are exempt from the CRI due to their limited spectral efficiency. A new color rendering index, according to the CIE, should be used for all lighting types.(Rea, 2008).

According to the Kruithof effect, people's preferences for altering brightness and color temperature affect their reaction time. Illumination with low color temperatures is preferred over high color temperatures, according to this rule.(Kruithof, 1941). Even though the Kruithof effect isn't well documented, there is evidence for it.(Davis, 1990). After a given time in a room, people cannot compare lamps based on their color temperature anymore. It is aware of the cultural and environmental influences on people's color choices and the standard lighting methods in various locations.(Van Den Wymelenberg, 2014).The high color has recently been contested. The use of temperature light to increase people's alertness has the potential to be effective. These hypotheses require more study before they can be put to use in lighting design. Light homogeneity might be helpful or detrimental depending on the space's purpose, and the activities carried out. It is preferable to have a homogeneous lighting environment, as uniform lighting might make it difficult to discern between different artifacts. Illumination levels are frequently specified in light recommendations and rules about job areas and their surroundings.(Wijayatunga, 2003). Interior lighting architecture is mainly concerned with light levels, although visual system design deals with reflected light. The task should be adequately lighted in the surrounding environment when it comes to workplace lighting. When deciding on a lighting system, take the space's surface reflectance into account. The capacity to concentrate and direct light where needed most is one of the numerous advantages LEDs have

over traditional fluorescent lighting systems, which are less efficient. As a result of this technique, lighting energy efficiency will improve in the future.(Cheng, 2006).

Much light or not enough light is produced by glare. Discomfort glare is the most common problem with indoor illumination, whereas disability glare is a different type of glare. Discomfort caused by artificial light sources, luminaries, windows, or other bright surfaces is referred to as photophobia(Boyce P. H., 2003). Discomfort glare must be addressed according to specific standards and norms. In the actual world, the current glare indices are suitable for assessing the amount of discomfort glare produced by a variety of fluorescent light luminaries in various interior settings. problems with brightness and size of the glare source about its surroundings when it is employed as a source of glare(Waters, 1995). A luminaire's array of LEDs may produce luminaires of many shapes and sizes since LEDs are small point sources that output a significant amount of light.

Object specular reflections, known as veiling reflections, reduce the contrast between visual tasks.(Rea M. S., 1981). The deciding factors are how glossy the surface is and how small the lighting difference is (e.g., luminaires, windows, bright walls). Shiny things, like paper, glass, and computer screens, can cause veiling reflections. As several computer screen uses in larger spaces, care needs taking to prevent reflections of light from the screens inside the task area(Osterhaus W. H., 2015). For lighting design, it is critical to understand how different viewing directions will be affected by the placement of permanent luminaires. Using light shields to prevent maximum veiling reflections in the standard viewing directions should be avoided when changing work areas and the geometry of working circumstances. With proper luminaire location, the same visibility conditions may be achieved with less energy than poor luminaire positioning, resulting in veiling reflections that reduce visibility.(Worthey, 1989).Light cannot be suitable for vision because of the shadows, but it can also be good since it creates an eye-catching, stunning visual mood. The usage of shadows determines whether they have a comfortable or awkward appearance.(Boomsma, 2014)When observing how light falls on an item, it is essential to have an equal dispersion of light. If researchers want to find out more about lighting efficiency, look at the shadows of objects in greater depth: the light side, shadow side, cast shadow, and presence of reflected light are all things to consider.(Bear, 1992). Scientific research and innovative lighting applications will be strengthened with the help of this device.

When light varies at a specific frequency, a flicker is created. Flickering is common in alternating current-powered lighting fixtures. The variance in emissions is determined by the amount and intensity of the fluctuation.(Halpin, 2003). Flickering lights are generally an

eyesore, yet they may be employed for amusement when they are needed. Even flicker, according to some, poses a health risk. The use of high-frequency ballasts or fluorescent and high-intensity discharge lights can reduce flickering caused by electronic ballasts.(Brundrett, 1974).The eyes are where we see the bright world, but the brain is where the information is processed. The light scene assesses itself in light of prior perceptions and references. There are numerous aspects to the bright environment to consider, including whether or not people who join it will appreciate it more or less. Aesthetics, emotions, and mood may all be influenced by changes in brightness and hue, with the impact of lighting heavily influenced by the people and their emotional states.(Tomassoni, 2015). Lighting setups that fail to meet user expectations, although meeting all technical specifications, are never acceptable. Unpleasant working circumstances, such as poor lighting, can have a detrimental influence on productivity and morale.(Boyce P. R., 2010).

Light has a profound effect on the senses and the visual system, and this influence is not limited to vision alone. Human circadian photoreception and sleep rhythms are controlled by light's non-visual, non-image-forming (NIF) or biological impacts. Much of what we do in a day is dictated by our internal biological clock. We control sleep, body temperature, and hormone production. Numerous hormones, such as those that direct the body to sleep and control stress, are regulated.(Wirz-Justice, 2006).The biological clock may be regulated by short-wavelength light, according to some research.(Lavie, 2001).There is a great deal of mystery surrounding the impact of light on people, and no definitive answers can be provided at this time. More research is needed to fully comprehend light's non-visual impacts as well as its biological consequences. It should be designed so that workers have the proper visual conditions to do their jobs when it comes to lighting. An individual's physical and mental productivity can be affected by the luminous environment's impact on human physiology and psychology.(McColl, 2001) . Research is needed to understand better how lighting affects visual behavioural activities and cerebral responses and how lighting affects the body.

Statement of the problem

LED lighting systems have surpassed all other types of artificial luminaires in terms of worldwide adoption. For the most part nevertheless, current lighting systems in India employ linear and compact fluorescent luminaires. Only a few medium and small-scale manufacturers are presently making LED lights. Thus, there are not any LED standards in place yet. As a result, determining the proper lighting settings for various types of products can be challenging. To find a better solution, it is essential to compare LED lighting's environmental, technological,

and economic aspects to other existing systems. The big concern here is how the lighting systems in business buildings affect people's performance. The management is constantly interested in the performance of its employees, and the anticipated level of performance is directly related to the workplace conditions. As a result, the link between cognitive ability and human performance was examined in this study. The Circadian System and specific levels of Discomfort were identified in the literature to hurt human performance. Therefore, the study used them as a mediator and assessed their influence on cognitive function and human performance.

Objectives

1. Evaluate human performance under LED lighting system in commercial building regarding: -Visual Performance (VP), Motor Performance (MP), Task Performance (TP), Cognitive Performance, Human Performance, and Work Life.
2. To assess the direct effect between Cognitive Performance and Human Performance
3. To identify the role of Circadian System (M1), and Discomfort (M2) between Cognitive Performance and Human performance

Hypotheses

H_0: There is no significant effect between Cognitive Performance and Human Performance

H_0: There is no significant evidence that Cascadian System (Mediator) is influencing human performance

H_0: There is no significant evidence that Discomfort (Mediator) is influencing human performance

Research Context and Methodology

Driven lighting systems are now the most widely used and dependable in the world. Compact fluorescent light bulbs are used in India's current lighting systems for the most part. Even though there are a few small and medium-sized LED producers, there is no industry standard for LED production. As a result, estimating the amount of light all types of produce require is difficult.

The goal of this research was to find out how LED illumination affects human performance.

An organized questionnaire was utilized to gather information from employees of various government and commercial sector organizations. The research focused on the

Trivandrum area because Trivandrum is Kerala's capital and home to most of the state's administrative offices. Respondents were drawn from government and private sector offices using a stratified random sampling approach. Offices were divided into floor office units and single office rooms, with LED lighting systems required in all of them. Two hundred samples were chosen for the study after the reliability and genuineness of obtained data were checked because the entire population list was unavailable.

Scope and Justification of the Study

As a result of this research, we set out to determine how well LED and conventional (linear fluorescent, compact fluorescent, and incandescent) lighting systems perform luminously, how well people perform, and how much they cost in the most common luminaire applications currently found in the environment. The popularity of LED lighting systems has overtaken that of all other kinds of fabricated luminaires. In contrast, linear and compact fluorescent luminaires are used in most Indian lighting systems now in use. No LED standards exist, despite just a handful of medium and small firms currently producing LED lights. As a result, establishing the precise illumination requirements for each product is challenging to do. Compare the environmental, technological, and economic factors to the alternatives now accessible to discover a better solution.

EVALUATION OF HUMAN PERFORMANCE UNDER FOLLOWING ASPECTS

1. Visual Performance (VP)
a. Visual Size (VP1)
b. Luminance contrast (VP2)
c. Colour Difference (VP3)
d. Retinal Image Quality (VP4)
e. Retinalilluminance (VP5)
2. Motor Performance (MP)
a. Maintain Pace during the task (MP1)
b. Sitting Upright
c. Body comfort
3. Task Performance (TP)
a. Routine Task Performance
b. Adaptive Task Performance

c. Creative Task performance

d. Completion of Task Performance

4. Cognitive Performance

5. Human Performance

6. Work Life

a. Management

b. Motivation

c. Personality

d. Expectation

e. Culture

f. Context

g. Visual Perception of environment

Mediators

7. Circadian System (M1)

a. Time of Day (C1)

b. retinal illuminance (C2)

c. Light Spectrum (C3)

8. Discomfort (M2)

a. Negative Mood (D1)

b. Visual Discomfort (D2)

c. Discomfort to Visual Message (D3)

d. Glare (D4)

e. Flicker (D5)

f. Eye pain (D6)

g. Fatigue (D7)

Here, the study was analysed the mediation effect of circadian system, discomfort between Cognitive Performance and Human performance.

i.e.,

Cognitive Performance (CP)----------Human Performance (HP) (Direct Effect)

Cog. Per. (CP)----Circadian System (M1) ---Human Perf. (HP) (Indirect Effect)

Cog. Perf. (CP)----Discomfort (M2) ---Human Perf. (HP) (Indirect Effect)

STRUCTURAL EQUATION MODELLING

The Model fit index indicates that the present model was fit for structural equation modelling i.e., CMIN NPAR p-value is .071 and RMSEA value is 0.043 and FMIN is 0.401. which are indicating that model is having goodness of fit.

Structural Equation Model - Figure 1

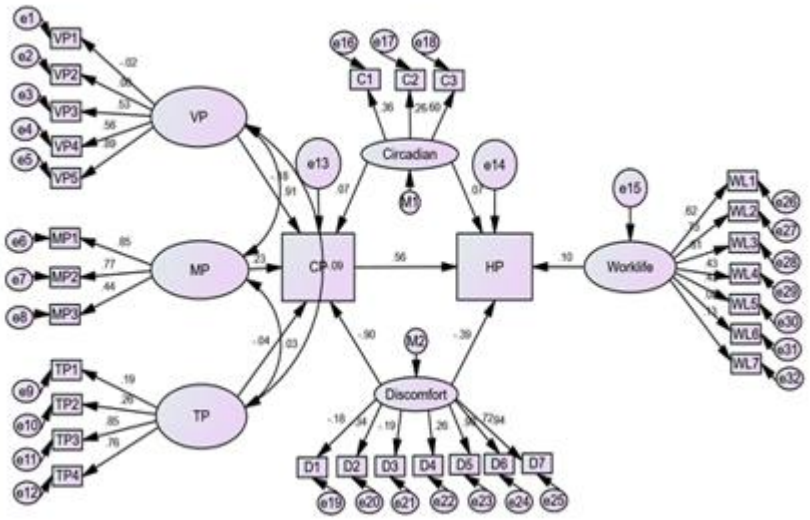

Table 1 Regression Weights and Standardized Regression Weights Estimation							
			Estimate	S.E.	C.R.	P	SRW Estimate
CP	<---	VP	-.596	.621	-.961	.337	-.176
CP	<---	TP	-.153	.168	-.907	.364	-.042
CP	<---	MP	1.647	1.321	1.247	.212	.230
CP	<---	Circadian	.525	.461	1.139	.255	.065
CP	<---	Discomfort	-1.580	.074	-21.324	***	-.897
HP	<---	CP	.508	.068	7.448	***	.562
HP	<---	Circadian	.493	.341	1.445	.148	.068
HP	<---	Discomfort	-.614	.124	-4.953	***	-.386
HP	<---	Work life	2.094	1.485	1.411	.158	.101
Source: Primary Data (Structural Equation Model)							

Here the result indicates that effect of Visual performance (VP), Motor Performance on Cognitive performance and Task performanceare not statistically significant. Effect of Cognitive performance (CP) on Human Performance (HP) is also statistically significant in the prediction of Cognitive Performance (CP) and also Circadian is not significant to predict the CP. On the other hand, it could be seen that Discomfort is able to predict the cognitive performance of an employee i.e., result is statistically significant. On the other hand, it could be seen that, Cognitive Performance is able to predict the Human Performance and the

Circadian system is not statistically significant, while discomfort is statistically significant with Human performance. In the case of Work life, it could be seen that effect of work life on Human performance is not statistically significant. Table is also illustrating the Standardized Regression Weights Estimation, based on the estimation it can be inferred that if the Discomfort goes by 1 standard deviation, Cognitive Performance will go down at -897, in the case of HP and CP, it could be seen that if Cognitive performance goes up by 1 standard deviation, the Human Performance will go up by .562 SD. In the case of Discomfort and Human Performance, it can be concluding that if the Discomfort goes up by 1 standard deviation, then Human Performance will come down at -.386 SD.

Covariance and Correlation							
			Estimate	**S.E.**	**C.R.**	**P**	**Correlation**
TP	<-->	MP	.018	.046	.394	.693	.035
VP	<-->	MP	.504	.097	5.168	***	.907
TP	<-->	VP	-.094	.097	-.968	.333	-.085
Standardized Total Effect							
	MP	**VP**	**TP**	**Discomfort**	**Circadian**	**Work life**	**CP**
CP	.230	-.176	-.042	-.897	.065	.000	.000
HP	.129	-.099	-.024	-.890	.104	.101	.562
Standardized Direct Effects							
	MP	**VP**	**TP**	**Discomfort**	**Circadian**	**Work life**	**CP**
CP	.230	-.176	-.042	-.897	.065	.000	.000
HP	.000	.000	.000	-.386	.068	.101	.562
Standardized Indirect Effects							
	Discomfort		Circadian				
HP	-.504		.037				

Based on the result, it could be seen that total effect of discomfort towards CP and HP were -.897 and -.890. When compared to direct and indirect effect, it could be seen that Direct effect of Cognitive Performance (CP) towards Human Performance (HP) was .562, which means that if the CP go up by 1 SD, Human Performance will also go up by .562 SD. Hence it can be inferred that Cognitive Performance is positively influencing the Human performance which means cognitive performance increasing the human performance. In the case of Mediation effect, it could be seen that if the discomfort is disturbing between Cognitive performance and Human Performance, then the human performance will go down by -.504 SD from Standardized Direct effect -.386. Which means the influence of discomfort will reduce the human performance.

Based on the result and interpretation, it can be concluding that, Cognitive Performance is significantly influencing the human performance and the discomfort is disturbing them and reducing the human performance. Based on this fact, the null hypotheses standrejected and

concludes that there is a direct positive effect between cognitive performance and human performance, and there is significant evidence that discomfort is negatively influencing the human performance and it reducing then effect of cognitive performance.

CONCLUSION

Human performance is very much important in every sector and it's depended on various multi-dimensional factors. Here the study has been analysed the direct and indirect effect between Cognitive Performance and Human performance of an employee. Simultaneously, study is saying that cognitive performance is not depending on the visual, and task performance. On the other hand, it could be seen that, Cognitive performance is affected by discomfort and the motor performance influence towards the Cognitive performance is positive but not significant. In the case of work life, it has no influence towards the human performance and also discomfort is influencing the human performance. While analysing the mediation effect, it was found that, direct effect of Cognitive Performance will increase the Human Performance, but the existence of discomfort will reduce the human performance. Which means that negative mood change, visual discomfort, discomfort to visual message, Glare, Flicker, Eye pain, and fatigue are reducing the human performance.

Based on the findings from the study, it could be seen that visual, motor and task performance are not influencing the cognitive performance, at the same time visual discomfort, discomfort to visual message,Glare, Flicker are decreasing their performance. hence, the study is suggesting that visual performance should be measure on the basis of various discomforts faced by the employee from their work place lightening.

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