OKU Fen Bilimleri Enstitüsü Dergisi
8(2): 985-999, 2025

OKU Journal of The Institute of Science and Technology, 8(2): 985-999, 2025

Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi

Osmaniye Korkut Ata University Journal of The Institute of Science and Technology

İşyeri ve Çalışan Verimliliğini Etkileyen Faktörler

Safiye Nazmiye ÖZTÜRK[1,2*], Tülay ÖZTÜRK[3,4]. Barış ÖZTÜRK[5], Ahmet Mert ÖZTÜRK[6]

[1]Department of Cyber Security, Istanbul Ticaret University, Istanbul, Türkiye
[2]Occupational Health and Safety Specialist
[3]Department of Nephrology, Sancaktepe Sehit Prof. Dr. Ilhan Varank Training and Research Hospital, Istanbul, Türkiye
[4]Occupational Physician
[5]Department of R&D, BEOTEK Electricity and Automation, Istanbul, Türkiye
[6]Department of Operational Technology Engineer, Tupras, Istanbul, Türkiye

[1]https://orcid.org/ 0000-0002-3527-3258
[3]https://orcid.org/ 0000-0001-8393-2580
[5]https://orcid.org/ 0009-0007-8701-4147
[6]https://orcid.org/ 0009-0008-4641-4440
*Sorumlu yazar: nnazmiye82@gmail.com

Derleme

Makale Tarihçesi:
Geliş tarihi: 16.08.2024
Kabul tarihi: 21.10.2024
Online Yayınlanma: 12.03.2025

Anahtar Kelimeler:
Aydınlatma
Hasta bina sendromu
Renk sıcaklığı
Renk geriverim indeksi

ÖZ

İş sağlığı ve güvenliği; çalışma ortamında hem işçilerin verimli çalışması, iş performansı, tatmini, motivasyonu sağlanması hem de iş kazalarının önlenmesi açısından önemli meslek alanlarından biridir. Ülkemizde çoğu çalışma alanlarında aydınlatmanın çalışanın sağlığını, verimliliğini, motivasyonunu, iş refahını nasıl etkileyeceği dikkate alınan konular arasında görülmemektedir. Çalışma ortamı denildiğinde sadece ofisler olarak değerlendirilmemelidir. Örneğin AVM'ler, kafeler de birer çalışma ortamıdır ve yanlış aydınlatma sistemleri kullanılması çalışanları ve doğal olarak buraya gelen müşterileri olumsuz yönde etkileyebilir. Bu makalede bina içi tasarımlardan biri olan aydınlatma ve konuları arasındaki renk sıcaklığının, renk geriverim indeksinin çalışan sağlığı ve performansı üzerindeki etkileri araştırılmış olup, gün ışığı ve yapay ışığın işçilerin verimliliğini, motivasyonunu, iş tatmini ve üretkenliği nasıl etkilediği üzerinde durulmuştur. Yeterli gün ışığı alamayan ya da yeterli aydınlatma olmayan çalışma alanlarında, çalışanların motivasyonunun, verimliliğinin ve üretkenliğinin aynı zamanda çalışma saatlerinde işi sürdürebilme istekliliğinin olumsuz etkilendiği yapılan araştırmalarda görülmüştür. Diğer taraftan yeterli ışığın alınamadığı ortamlarda oturma pozisyonlarından kaynaklanacak sebeple hem iskelet sisteminde bozulmalar hem de ekranlı araçlarda çalışırken aşırı yorulmadan dolayı göz hassasiyetlerinde artma olduğunu saptanmıştır. İşverenin, çalışma ortamında işçi sağlığı ve güvenliği açısından hem yeterli gün ışığı hem de yapay ışığı sağlaması önem arz etmektedir. İyi yapılandırılmış bir aydınlatma sadece işçilerin sağlığı için değil, işverenler ve iş yeri ortamında işçilerin daha üretken olması, hata ve kaza oranları, devamsızlığın azaltılması, daha iyi iş güvenliği ve sağlığı açısından önemlidir. Burada iş performansını ve motivasyonunu, huzuru etkileyen aydınlatma, CCT ve CRI kavramları ve hasta bina sendromu üzerine değerlendirme makalesi yapılmıştır.

Factors Affecting Workplace and Employee Productivity

Research Article

ABSTRACT

Article History:
Received: 16.08.2024
Accepted: 21.10.2024
Published online: 12.03.2025

Keywords:
Artificial lighting
Sick building syndrome
Color temperature
Color rendering index

Occupational health and safety are one of the most important occupational fields in terms of ensuring efficient work, job performance, satisfaction and motivation of workers and preventing occupational accidents in the working environment. In most workplaces in our country, how lighting will affect the health, productivity, motivation and well-being of the employee is not among the issues considered. When the working environment is called, it should not only be considered as offices. For example, shopping malls and cafes are also working environment, and the use of incorrect lighting systems can negatively affect employees and customers who naturally come here. This article explores the effects of color temperature, color rendering index between its subjects and lighting, which is one of the building interior designs, on employee health and performance are investigated, how daylight and artificial light affect workers' efficiency, motivation, job satisfaction and productivity and sick building syndrome (SBS) are emphasized. Well-structured lighting is important not only for the health of workers, but also for employers and workers in the workplace environment in terms of increased productivity, reduced error and accident rates, reduced absenteeism, better occupational safety and health.

To Cite: Öztürk SN., Öztürk T., Öztürk B., Öztürk AM. İşyeri ve Çalışan Verimliliğini Etkileyen Faktörler. Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi 2025; 8(2): 985-999.

1. Introduction

As the earth revolves around its axis, we human beings have a physiological, biochemical and behavioral cycle that is constantly repeated. SBS has been acknowledged by the World Health Organization (WHO) as a health problem caused by the building environment and is included in the Occupational Health Declaration. In recent years, natural daylight and artificial lighting have become a concern in Engineering and Architecture and Occupational Health and Safety (OHS). Failure to reflect enough natural or artificial light in work environments can create stress and psychological states in different ways in employees. Regarding work motivation and performance, situations such as stress and anxiety can cause different situations in employee psychology during working hours, because negativities in the workplace environment directly affect the performance and motivation of the employees and their peace. Many environmental factors certainly affect employees' motivation and mood in the workplace. Today, when the quality of life is quite low through the process of the Covid 19 pandemic, many employees want to focus on the work instead of thinking about the stressful, negative situations in the house when coming to work, but if the environmental factors in the workplace environment create negativity, the efficiency of these works, performance, it will affect their productivity, motivation and job satisfaction, peace of mind, and research continues to be done on this subject (Öztürk et al., 2021).

Along with the developing technology, it is seen that there are changes in working conditions and the habits of employees in doing the job. If we evaluate the business changes in terms of past and present, we can take a simple example: sales-marketing departments' work, which was previously done using many documents, is now carried out through various programs with digital transformation in the computer environment. While the advancement of technology is positive, on the other hand, the complexity of the systems and the lack of competence of the personnel can lead to various problems. Therefore, in parallel with technology, the changing demands and requirements of customers and the desire to finish the work in a shorter time, working at a faster pace and for longer periods directly affect

the performance and motivation of employees. As such situations increase anxiety in the mind, it will be a situation that directly affects productivity, performance and motivation. For this reason, employers need to develop environmental factors that affect employees negatively in line with the demands of their employees or regulate them depending on the working environment. It should be considered that environmental factors can affect not only one employee but also many employees.

Daylight is one of the indispensable and necessary resources for all living things. For this reason, visual disturbances such as distraction due to physiological and psychological reasons, and temporary loss of vision due to glare, reflection and shadow should be eliminated by providing daylight and correctly selected and calculated artificial lighting devices in buildings with closed areas such as offices and factories in 7-24 workplaces (Schulzová and Bošová, 2019; Öztürk et al., 2021). Figure 1 shows that the situations affecting workers in the workplace. In office environments, employees may suffer from computer screen glare in daylight due to incorrect positioning of computers. This is sometimes due to the building plan, sometimes due to the incorrect location of installations or the placement of desks in the wrong places.

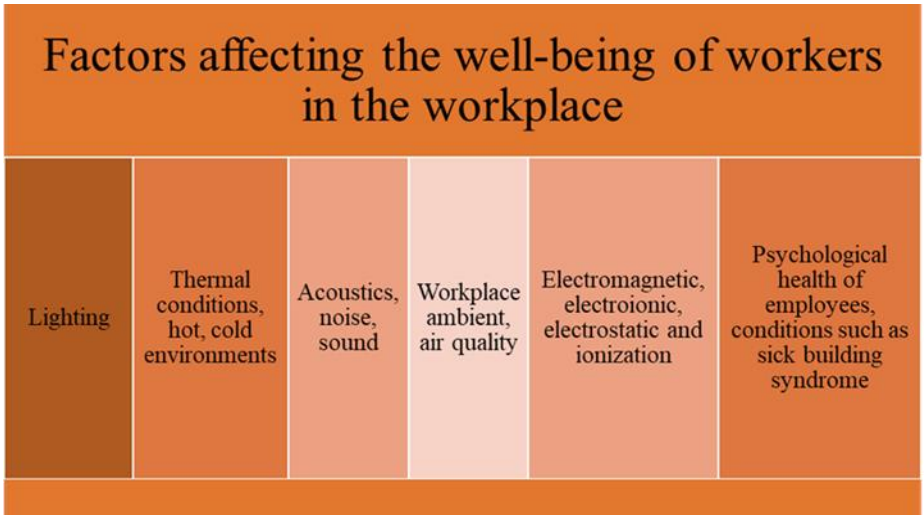

Figure 1. Factors affecting employees' work motivation, performance and peace of mind in the workplace (Schulzova and Bosova, 2019; Öztürk et al., 2021).

The environment in workplaces is the place where employees spend the most time and includes physical conditions that affect many factors from the senses of the workers to their well-being, peace of mind and motivation. If employers expect maximum efficiency, performance and productivity from their workers, they should consider that this is closely related to the physical and mental well-being, happiness and restfulness of their employees and the workplace space and design (Schulzova and Bosova, 2019; Öztürk et al., 2021).

Malik, Qayyum and Fatima (2021) reported that female employees were more negatively affected by sick building syndrome than male employees when evaluated under sanity and SBS at the site of the work.

It is important for workpeople to adapt to the changing and ongoing challenges in the workplace environment, to remain strong against the competition around them and to improve themselves. Here, when we evaluate the past business life in terms of competition at work, we can think that the competition was less than it is today due to the low number of educated and skilled personnel and the need for manpower in workplaces. Today, however, the high number of educated people and the increasing complexity of work lead to a more competitive workplace environment. It is also important for employers to be able to maintain the standard set by ensuring the well-being and peace of mind of employees in the workplace environment and increasing their motivation. Weaknesses in the environmental factors that need to be maintained and adhered to the set standards in the indoor environment will cause ongoing fatigue, headaches, irritability, reduced mental and physical productivity and performance, as well as a decrease in material spiritual and emotional well-being, and a decrease in job forecasting (Schulzova and Bosova, 2019; Malik and Qayyum et al., 2021; Öztürk et al., 2021).

In some studies on the effectiveness of lighting on work-employee performance in the workplace, it has been reported that employee vision increases with increasing illumination, if they are exposed to light at night, it has an awakening effect and this is related to the cold CCT (Correlated Color Temperature) level, as illumination increases, employee concentration can increase, communication and social behaviors are improved at warmer CCT value and low illumination level (dim environment) (Te Kulve et al., 2018; Schulzova and Bosova, 2019; Öztürk et al., 2021).

2. Sick Building Syndrome

SBS is one of the reasons that has a great impact on work performance and motivation as well as affecting the attendance, efficiency and productivity of employees, which has economic consequences every year that directly affect workplaces (Nduka et al., 2018; Afolabi et al., 2020; Sarkhosh al., 2021). SBS include components such as inadequate, poor lighting, inadequate ventilation, humidity, temperature and noise. In the definition of SBS by the WHO in 1983, it was stated that symptoms such as headaches, dry skin, irritation in the eyes, nose and throat, dizziness, drowsiness, hypersensitivity, cough, and nausea were observed (Morris and Dennison, 1995; Nduka et al., 2018; Afolabi et al., 2020; Hoang et al., 2020; Sarkhosh al., 2021; Wang et al., 2022; Hu et al., 2023). The important point here is that the problem starts when you enter the building or environments such as workplaces and factories and disappears when you move away from these places or when you leave. These symptoms are more likely to be seen in more competent experienced, professional and administrative personnel and personnel working in an office environment. These symptoms may vary according to the workplace environment, but they are not specific and do not vary much in employees.

SBS should be considered not only in the home environment but also in the workplace environment, since most of the time is spent in the workplace, except for vacations. Sometimes, workers may experience fatigue, headaches, difficulty concentrating and other symptoms that cannot be identified as

soon as they arrive at the workplace. This can be caused by inappropriate workplace lighting, inappropriate and non-ergonomic workplace design, ambient noise, ambient temperature and humidity, anxiety about being able to do and complete the work, and indoor environmental problems.

In terms of lighting, fluorescent lamps used in the past, which can still be found in some workplaces today, can cause the production of photochemical fumes due to the materials used. This can reduce the amount of oxygen that should be sufficient in the working environment where employees are located. In addition, the lack of adequate light can create a problem for employees to focus on work.

One of the environmental factors considered in SBS is lighting. Because the sensitivity of each worker to light may differ. The quality of lighting systems used in workplaces and the amount of light perceived by workers may be more or less. In addition, sensitivity to light may vary depending on age and visual ability, the type of work performed, i.e. visual difficulty (Morris and Dennison, 1995; Nduka et al., 2018; Afolabi et al., 2020; Hoang et al., 2020; Sarkhosh al., 2021; Wang et al., 2022; Hu et al., 2023). For example, the white light emitted by fluorescent lamps may cause headaches, including eye fatigue, and a decrease in work efficiency and performance, or the excessive brightness and glare of the selected luminaires, insufficient contrast level may cause visual stress in employees, headaches and eye irritation. It may cause employees to take leave and go for repeated hospital examinations.

3. Lighting Concepts

3.1. Illumination

It is the intensity of the light flux event on a surface. It is the method used to capture sufficient light by lighting standards and continues to be investigated as a variable affecting human performance (Konstantzos et al., 2020).

Inadequate light obtained from the lamps used in lighting systems, or problems caused by concepts such as glare, flickering and contrast that may be seen in the devices used in lighting and which are undesirable, as well as premature fatigue in the employees, eye strain due to further blinking, dry eye and related headaches are conditions that can affect job satisfaction, peace of mind and performance in employees.

Color rendering efficiency (CRI) is considered the best source of daylight. Studies have shown that daylight during the day in the workplace affects perception, health and comfort of employees. It has been observed that workers are negatively affected in cold thermal environments with low daylight intensity, while they are more comfortable in warm conditions (Jiang et al., 2022).

In building design, floor and ceiling heights are important, and the devices selected for lighting should be determined by considering the width and height of the working environments and windows, because the lack of sufficient natural light or artificial light in the workplace environment can cause stress and work reluctance for employees. In addition, if combined with other environmental or managerial problems, it is difficult for employees to continue working, in the most general sense, the answer that employees will give will be "I was not peaceful in the workplace environment".

Glare that may arise from incorrect choices made in the installation of lighting systems can cause work stress. The fact that it directly affects vision, especially in those who work in fine work, can create psychological pressure on the employee.

Inadequate natural and artificial lighting and the increase in the use of computers in workplaces have led to an increase in work stress in workplaces along with environmental factors. Today, there is a transition to LED lighting systems instead of lamps that can reduce the amount of oxygen in the environment due to the toxic and photochemical reactions emitted from traditional lamps.

Factors arising from building designs, lack of ergonomics, insufficient access to daylight due to the layout of the workplaces, and defects in artificial lighting can lead to different causes of stress in employees and cause SBS in office or factory workers.

In compliance with Occupational Health and Safety, lighting, which is one of the subjects explained in interior design in the Department of Architecture as well as Electrical and Electronics Engineering, should help to elevate effectivity and prolificacy as well as provide employees in offices or factories with the opportunity to work by feeling safe. It is certain that overly bright or inadequate lighting will create different stress effects on each employee. It will cause eye itching, dry eyes, premature fatigue of the eyes and, over time, severe eye impairment. For example, different situations may arise depending on their working conditions, especially in the office environment and those working with screen devices such as computers. In addition to work anxiety and stress, SBS and the existing lighting system will also harm employees. Employees will be uncomfortable with the existing lighting systems and will want to reduce or increase them. In this case, it will negatively affect job satisfaction, motivation, adaptation to the workplace environment, performance and productivity as it will create negativity in other employees. When new workplaces are defined in our country, we need to think of offices in modern commercial buildings. In these workplaces, there are multi-user, collaborative, fast working tempo and transitions between units (Despenic et al., 2022).

Lighting requirements among employees may vary according to various reasons. In this case, it will be difficult to achieve results that will delight and satisfy each employee at work and increase their productivity, because while such modern office type buildings are being built, it is not clear which business areas will be used, they are completed using general lighting design and devices. The type of lighting that workplace employees will need for their work should be selected. Similarly, in a factory environment, a similar type of lighting is important for workers working in different tasks and places. Contrasting luminaires; high illumination in one place and dim lighting in another place may cause dissatisfaction and conflicts among employees (Konstantzos et al., 2020). In addition, it will not only delay the work, but also cause the worker to work more slowly, affecting the worker's feelings such as alertness, stress and mood, satisfaction, and decreasing peace and motivation in the workplace environment.

Nowadays, since almost every work is done with screen tools such as computers, the glare on the screens, the light level in the lamps used to illuminate, flickering, and the contrast level is not suitable may cause problems in work satisfaction and performance of the workpeople. Here, CCT and CRT values, which are lighting terms from Electrical and Electronics engineering subjects, are also important in the selection of lamps for the lighting problem. The lamps used in the workplace environment should be close to natural daylight. When selecting lamps, they should be selected to emit less heat to the environment, not to create dim-darkening environments when lighting and energy efficiency should be planned. One of the important points here is that workers working together in environments such as offices may have different sensitivity to light. Above a certain level, there may be problems such as decreased vision and migraine. These workers may request that the number of lamps required in the environment be reduced and dark curtains be used on the windows. This can lead to a lack of motivation, reluctance to enter the work environment and sick building syndrome in other employees, affecting peace and job satisfaction at work, causing conflicts between employees and a decrease in tolerance levels. The second is the placement of desks; in many office environments, the placement of desks closes to windows, the arrival and reflection of daylight on screen devices can cause temporary vision loss in employees. Interior layout is also important here.

Weaknesses in lighting design, because design processes are carried out based on architectural plans, not paying attention to the location of workplaces, factories and offices in the external environment, and the environmental factors around them, not creating lighting plans for different requirements and tasks, lack of lighting laws and adequate administrative regulation, improper selection of luminaires, incorrect use of the concept called room-index ratio (Despenic et al., 2017; Katabaro et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022) cause the required lighting not to be obtained.

3.2. Brightness

The amount of light flux transmitted through a unit facet (Despenic et al., 2017; Katabaro et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022). Luminescence is measured and very few studies have focused on human performance. Luminance ratio or luminance contrast will vary across environments and surfaces and should be considered as an important consideration.

Brightness in the visual field affects visibility and visual comfort. The unit of brightness for a light source is the nit (candela/sq.m) (Despenic et al., 2017; Katabaro et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022). Building ceilings and walls, interior surfaces with appropriate brightness affect people's visual comfort. With a balanced and appropriate distribution of brightness, visual acuity, contrast adjustment and sensitivity are affected by the good functioning of visual functions, i.e. pupil contraction and movements, convergence. The formation of shadowy areas and unwanted brightness may limit the ability to see (Despenic et al., 2017; Sun et al., 2019; Katabaro et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022).

3.3. Light Color and Type

Among the selected luminaires and their characteristics, the associated color temperature, light rendering index, light intensity, light uniformity, spectral distribution are among the issues to be considered. Different types of lamps can directly affect workplace workers and their productivity. Because the color of light can cause decreased attention and loss of perception, cognitive confusion and decreased work performance (Despenic et al., 2017; Katabaro et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022).

4. CCT and CRI

The conditions affecting lighting such as illumination distribution, color temperature, color rendering, and intensity of the selected luminaires are effective in the perception of the image, which increases or decreases human visual activity (Sun et al., 2019). In addition, since all systems in the human body work in coordination with each other, workers' emotional, cognitive ability, executive functions and performance on the task can be affected by lighting systems. In terms of work efficiency, the lighting environment can positively or negatively affect the risk of making mistakes and accidents.

The color of the illuminant radiated from the luminaire used is the associated color temperature, and the view out of an object under a source of illumination relative to natural light is related to the color rendering index (Pulay et al., 2018). For a light source, it is described as its visual performance and determines the capacity of artificial light sources to reflect colors close to sunlight (Fumagalli et al., 2015). For CRI, daylight is accepted as 100% and evaluated between 0 and 100. At 0, the colors are observed as lifeless and pale, like each other, while as the value increases towards 100, it is seen that the colors are distinguished and vivid, that is, there is a clearer image (Ohno, 2000; Ozturk et al, 2022). Figure 2 indicates CRI index and Figure 3 explains CCT values.

Figure 2. CRI index values (Ohno, 2000; Ozturk et al., 2022; https://www.ledsmaster.com/; https://www.earthtronics.com/; https://www.ledyilighting.com)

The light color of visible light is reflected by a source of illumination, expressed in CCT. Its unit is Kelvin. The color of the light source is expressed in degrees Kelvin (Ohno, 2000; Ozturk et al., 2022; www.aydinlatma.org/cri-renksel-geriverim-indeksi-nedir.html;www.aydinlatma.org/renk-sicakligi-kelvin.html)

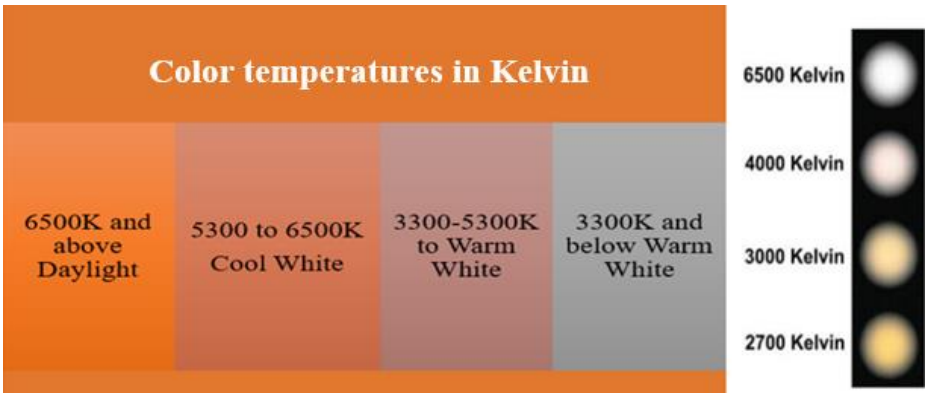

Figure 3. Color temperature values (Ohno, 2000; Ozturk et al., 2022; Fontana, 2023; https://www.ledsmaster.com/; https://www.earthtronics.com/; https://www.ledyilighting.com)

Since workplaces also consist of enclosed spaces, it is necessary to consider indoor lighting design because the objects in the illuminated place, such as wall color, light reflection properties from the surface, intensity, spectral power distribution, CRI and CCT values and color rendering through artificial light, should be considered not only as the properties of light sources, but also as a whole with indoor architecture (Ozturk et al., 2022; Fontana, 2023).

When cognitive function is considered in employees, it can be counted as problem solving, reasoning, planning, determining behaviors towards targeted points, complying with the given tasks, and adapting to transitions between different units (Ohno, 2000; Fumagalli et al., 2015; Despenic et al., 2017; Pulay et al., 2018; Jamrozik et.al, 2019; Katabaro et al., 2019; Sun et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022; Fontana, 2023).

The perception of light in an area depends on color temperature and color rendering index. CCT has an impact on the visual perception, cognition, job satisfaction, mood, peace, comfort, performance and productivity of employees in the workplace (Ohno, 2000; Fumagalli et al., 2015; Despenic et al., 2017; Pulay et al., 2018; Jamrozik et.al, 2019; Katabaro et al., 2019; Sun et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022; Fontana, 2023). These two factors, which are important in determining luminaire properties, are among the factors that determine the psychological and physiological states of the body in employees. When it comes to CCT, the Kelvin (K) value that is suitable or close to daylight in the workplace environment will positively increase the motivation and satisfaction of workers or office environment employees by affecting the characteristics such as cognition, i.e. the ability to comprehend, understand, remember, and the ability to quickly obtain and apply information in the workplace environment. Studies have shown that in workplaces where environmental conditions are suitable and

sufficient daylight is received, employees may have higher motivation and accordingly their performance increases (Ohno, 2000; Fumagalli et al., 2015; Despenic et al., 2017; Pulay et al., 2018; Jamrozik et.al, 2019; Katabaro et al., 2019; Sun et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022; Fontana, 2023).

Glare in workplace lighting will have a direct or indirect effect on the worker's vision. In this case, it is one of the situations that interfere with the vision of the employee and causes glare in the eyes, there is difficulty in continuing the work, because it can cause a feeling of fatigue both physically and mentally, and the other may be the discomfort that glare will cause in the employee, even if it does not interfere with vision (Ohno, 2000; Fumagalli et al., 2015; Despenic et al., 2017; Pulay et al., 2018; Jamrozik et.al, 2019; Katabaro et al., 2019; Sun et al., 2019; Konstantzos et al., 2020; Jiang et al., 2022; Fontana, 2023). For example, irritability, distraction, headaches.

In studies, it has been stated that the associated color temperature (CCT) in workplaces increases features such as alertness and performance in employees. It has been observed in studies that workers working under bright light have better mood, cognitive functioning, performance and alertness, ability to maintain work, and attention. The relationship between sleep and wakefulness is affected by light and dark environments, as there may be changes in the physiological and hormonal systems of workers in both daytime work and especially shift work (Van de Putte et al., 2022)

5. The Impacts of Daylight and Artificial Light on Workers' Health and Well-Being, Cognitive Function and Performance Use this Style for Level One Headings

Many studies have shown that daylight has a positive impact on health, for example, good quality sleep, improved vision, less eye strain, less headaches and depression. It is certain that low light in workplaces and offices can trigger eye defects such as myopia. It has been stated in studies that mental fatigue, stress, sleepiness and blood pressure decrease in those who sit in places that can receive natural light at workplaces or on windowsills, while depressive problems, sleepiness and physiological problems increase in employees who do not receive sufficient light (Allen and Macomber, 2022) and consequently affect work motivation and work-workplace well-being.

Light has important effects on cognitive function. It is important to maintain the circadian system and cognitive well-being in the cycle we call sleep and wakefulness. This is because the sleep-wake cycle is important for the functioning of memory, the execution of its function, its ability to learn, and the ability to maintain the functioning of memory, and depends on the regular functioning of the circadian rhythm. For example, when short wavelength and high intensity light systems are used, workers are more likely to stay awake in the workplace, and values closer to daylight in the morning, such as CCT: 5500-6500 K compared to CCT: 3000-3500 K, improve cognitive functioning and employee performance and motivation (Cedeño-Laurent et al., 2018; Allen and Macomber, 2022; Marberry et al., 2022).

In addition to all these, design and planning should be made considering summer and winter conditions. Considering that light has a stimulating effect, reducing the short wavelength and light intensity will cause a decrease in the desire of employees to stay awake towards the evening hours in workplaces and offices and an increase in the desire to fall asleep due to relaxation (Clements-Croome, 2006).

If workplaces such as offices and factories are considered as indoor spaces, non-visual effects will vary depending on light levels. Considering daytime and shift work, physiological, metabolic functioning, hormone levels, sleep-wake cycles, mood, immunity, and many other conditions and behaviors need to be maintained in harmony with the circadian system. Therefore, it is needful to maintain the light and dark cycles in a stable manner with properly designed and selected lighting devices during the 24-hour working period. A disruption in the circadian system of employees may conduce to an augmented risk of chronic and acute diseases in the workplace, such as diabetes, kidney and heart diseases, various types of cancer and accidents, as well as results that directly or indirectly affect the employer economically (MacNaughton et al., 2021). Establishing a light and dark cycle that will positively affect the worker is important for the healthy functioning of the circadian system and the rhythms it controls. Figure 4 specifies the impact of enlightenment on human performance.

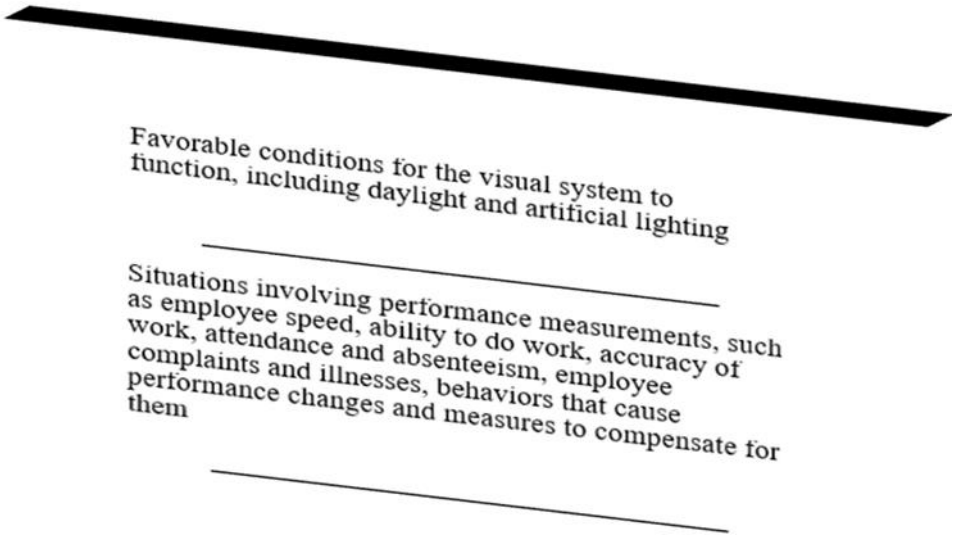

Figure 4. The importance of lighting on human performance can be explained in two ways (Abdou, 1997; Juslén and Tenner 2005)

6. Conclusion

Studies have shown that employee health and safety, performance, productivity and motivation are negatively affected in poorly designed workplaces and office environments. In the workplace environment, flicker, glare and noise from lighting devices can disturb employees. It has been stated that problems such as not using appropriate CCT and CRI values, glare, flicker or high brightness on one side and a dim environment on the other side cause excessive sensitivity, fatigue, dryness or tearing in the eyes, on the other hand, both mental and physical fatigue, adaptation to work in the workplace

environment, inability to focus and sleepiness, work accidents, and also reduce employee motivation and job satisfaction. Research has shown that the selection of user-oriented design elements in offices and workplaces is important and that the satisfaction and productivity of the employee in the workplace environment can be increased. At another important point, it has been emphasized to creation environments where sufficient daylight can be received in workplaces, because daylight is the best natural source of illumination for eye health and visual comfort in terms of color rendering and color temperature, color spectrum. One of the factors that optimizes the spatial appearance is a well-designed lighting system, which is important both from the point of occupational health and safety, employee welfare, motivation and environmental improvement.

Among the issues that are not found in many workplaces, but which need to be evaluated for employees, designs can be developed to control electrical lighting, dimming for those with eye sensitivity, that is, changing and regulating the brightness, and adjusting shading systems on windows.

Inappropriate lighting conditions: drowsiness, eye fatigue, headaches, employee satisfaction, participation, keeping cognitive ability alive, work attendance, work focus, as well as taking leave due to illness, absenteeism and negatively affecting employee performance and welfare, not only affecting the employee but also the employer in terms of cost. Health expenses also create a financial burden with a negative impact on the employer. By positioning daylight and artificial light in workplaces with advanced design strategies in the best way, unobstructed visibility, glare and shadow environments can be reduced, and the heat emitted from the devices used can be minimized.

Acknowledgment

The authors have not received any financial support for the research, authorship, or publication of this study. No conflict of interest or common interest has been declared by the authors.

Author Contribution

The authors contributed equally to the study.

Ethics Committee Approval

This study does not require ethics committee permission or any special permission.

References

Abdou OA. Effects of luminous environment on worker productivity in building Spaces. Journal of Architectural Engineering. 1997; 3(3): 124–132.

Afolabi A., Arome A., Akinbo F. Empirical study on sick building syndrome from indoor pollution in Nigeria. 2020; 8(E): 395–404.

Allen J., Macomber J. Healthy buildings: How indoor spaces drive performance and productivity. Harvard University Press; 2020 Feb 7.

Cedeño-Laurent J., Williams A., MacNaughton P., Cao X., Eitland E., Spengler J., Allen J. Building evidence for health: green buildings, Current Science, and Future Challenges 2018; 39: 291–308.

Clements-Croome D. Creating the productive workplace. Taylor & Francis; 2006 Feb 7.

Color Rendering Index (CRI) Versus color temperature – What are they? https://www.ledsmaster.com/knowledge/color-temperature/color-rendering-index-versus-color-temperature/

Complete Guide to the Color Rendering Index, Color Temperature, and LED Lighting. 2022 Dec 14 https://www.earthtronics.com/2022/12/14/complete-guide-to-the-color-rendering-index-color-temperature-and-led-lights/

Despenic M., Chraibi S., Lashina T., Rosemann A. Lighting preference profiles of users in an open office environment. Building and Environment. 2017; 116: 89–107.

Fontana L. Effect of indoor surfaces' spectral reflectance on the environmental light spectrum modification and on objects perceived color. Results in Engineering. Elsevier; 2023 Mar 1 ; 17: 100805.

Fumagalli S., Bonanomi C., Rizzi A. Experimental assessment of color-rendering indices and color appearance under varying setups. Journal of Modern Optics 2015; 62(1): 56–66.

Hoang Quoc C., Vu Huong G., Nguyen Duc H. Working conditions and sick building syndrome among health care workers in Vietnam. 2020; 17(10): 3635.
https://www.ledyilighting.com/what-is-cri/

Hu X., Li N., Gu J., He Y., Yongga A. Lighting and thermal factors on human comfort, work performance, and sick building syndrome in the underground building environment. Journal of Building Environment 2023; 79(7): 107878.

Jamrozik A., Clements N., Hasan SS., Zhao J., Zhang R., Campanella C., Loftness V., Porter P., Ly S., Wang S., Bauer B. Access to daylight and view in an office improves cognitive performance and satisfaction and reduces eyestrain: A controlled crossover study. Building and Environment. Pergamon 2019; 165: 106379.

Jiang Y., Li N., Yongga A., Yan W. Short-term effects of natural view and daylight from windows on thermal perception, health, and energy-saving potential. Building and Environment 2022; 15: 208:108575.

Juslén H., Tenner A. Mechanisms involved in enhancing human performance by changing the lighting in the industrial workplace. International Journal of Industrial Ergonomics 2005; 35(9): 843–855.

Katabaro JM., Yan Y. Effects of lighting quality on working efficiency of workers in office building in Tanzania. Journal of Environmental and Public Health 2019; 31814837.

Konstantzos I., Sadeghi SA., Kim M., Xiong J., Tzempelikos A. The effect of lighting environment on task performance in buildings–A review. Energy and Buildings 2020; 226: 110394.

MacNaughton P., Woo M., Tinianov B., Boubekri M., Satish U. Economic implications of access to daylight and views in office buildings from improved productivity. Journal of Applied Social Psychology 2021; 51(12): 1176–1183.

Malik U., Qayyum S., Fatima I. Physical work environment, sick building syndrome and mental health of factory workers. Journal of Contemporary Issues in Business and Government [Internet]. 2021; 27(1): 2021.

Marberry SO., Guenther R., Berry LL. Advancing human health, safety, and well-being with healthy buildings. Journal of Hospital Management and Health 2022. https://jhmhp.amegroups.org/article/view/7148/pdf

Morris A., Dennison P. Sick building syndrome: survey findings of libraries in Great Britain. 1995 Feb 7; 16(3): 34–42.

Nduka DO., Amusan LM., Akinbile B., Owolabi JD. Environmental physical quantities impact on emergence of sick building syndrome on users of public buildings in Lagos Nigeria. 2018 Feb 7; 9(10): 980–990.

Ohno Y. CIE fundamentals for color measurements. Society of Imaging Science and Technology 2000; 16: 540–545.

Ozturk SN., Onat M., Celik HH. 3d night ıllumination of aphrodisias open-air museum with LED Technology. Light and Engineering 2022, 30(1): 101–112.

Öztürk SN., Öztürk T. İş sağlığı ve güvenliği yönetim uygulamalarının çalışanların iş tatmini üzerine etkisi. Ohs Academy 2021; 4(3): 71–78.

Pulay A., Read M., Tural E., Lee S. Examining student behavior under two correlated color temperature levels of lighting in an elementary school classroom. 2018 Feb 7; 23(3): 58–69.

Sarkhosh M., Najafpoor AA., Alidadi H., Shamsara J., Amiri H., Andrea T., Kariminejad F. Indoor air quality associations with sick building syndrome: An application of decision tree technology. 2021 Feb 7; 188:107446.

Schulzova K., Bosova D. The development of ındoor environmental quality definition from vitruvius to the present. 11Th Architecture in Perspective 2019/11 Architekura V Perspektive 2019, October 2019, 38–42.

Sun C., Lian Z., Lan L. Work performance in relation to lighting environment in office buildings. Indoor and Built Environment 2019; 28(8): 1064–1082.

Te Kulve M., Schlangen L., Schellen L., Souman JL., van Marken Lichtenbelt W. Correlated colour temperature of morning light influences alertness and body temperature. 2018 Feb 7; 185: 1–13.

Van de Putte E., Kindt S., Bracke P., Stevens M., Vansteenkiste M., Vandevivere L., Ryckaert WR. The influence of integrative lighting on sleep and cognitive functioning of shift workers during the morning shift in an assembly plant. 2022; 09: 103618. Available from: https://doi.org/10.1016/j.apergo.2021.103618

Wang M., Li L., Hou C., Guo X., Fu H. Building and health: Mapping the knowledge development of sick building syndrome. Buildings 2022; 12(3): 287.

What is CRI? Everything you need to know. 2022 May 24.

Yoshi O. CIE fundamentals for color measurements: Ingenta Connect. IS&Ts NIP16: 2000 International Conference on Digital Printing Technologies [Internet]. 2000;16:540–545.