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Ergonomic Evaluation of CCTV Operators through REBA Posture Analysis, Work Sampling, and Work Environment Conditions

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ABSTRACT

CCTV monitoring activities are static tasks that require continuous visual focus and prolonged sitting, making operators prone to physical fatigue, visual impairment, and decreased performance. Common problems include non-ergonomic work postures, thermal discomfort, and lighting glare on monitors. This study aims to evaluate CCTV operator performance through a comprehensive ergonomic approach that includes posture analysis, work activity patterns, and environmental conditions. The methods used include work sampling to measure the proportion of productive and idle time, posture analysis using REBA to determine musculoskeletal risk, and measurement of environmental parameters such as temperature, air velocity, viewing distance, and lighting quality. The results showed a REBA score of 3 (low risk but improvement needed), operator focus time of only 8–10 minutes, normal idle time of 15 minutes, and an allowance of 17 minutes. Nighttime thermal conditions were below comfort standards, and glare was found to interfere with visibility. These findings confirm the need to redesign workstations and improve working conditions to improve CCTV operator performance.

INTRODUCTION

CCTV (Closed Circuit Television) surveillance systems are a key component in maintaining security in various sectors such as industry, education, offices, and public facilities [1]. The reliability of this system is highly dependent on the performance of operators who continuously monitor the screen [2]. These monitoring activities require a high level of concentration and visual accuracy, as operators must be able to detect small changes or important events in a short period of time [3]. However, the static and monotonous nature of the work makes operators highly susceptible to visual and physical fatigue [4], [5]. Work performed over long periods of time in a relatively unchanged sitting position, with minimal body movement, puts operators at risk of musculoskeletal complaints, visual impairment, and reduced ability to focus on their work. These conditions can affect operator performance in terms of the overall effectiveness of the safety system [6].

Various ergonomic problems are often found in CCTV operator working conditions, especially those related to workstation arrangements that do not comply with ergonomic principles. For example, monitors are placed at an angle that is not in line with the operator's line of sight, causing them to bend their neck or look up, which in the long term increases the workload on the neck and upper back muscles [7]. A similar situation was found at the research site, where the monitors were positioned above the operator's eye level, forcing the operator to maintain an upward neck angle throughout the monitoring period. In addition, working conditions such as temperature, humidity, lighting, and glare often did not meet comfort standards. In the server room where operators perform monitoring activities, the room temperature at night was recorded at 18–20°C, well below the thermal comfort limits recommended in Permenaker No. 13 of 2011. This type of thermal discomfort can affect the physical endurance of operators, increase muscle tension, and interfere with work focus [8], [9].

In addition to posture and temperature, lighting issues are also a critical factor in visual monitoring work. [10]. Glare or light reflection on CCTV monitors can interfere with the clarity of the images seen by operators, reducing observation quality and increasing visual load [10]. Previous studies have shown that uncontrolled glare can accelerate eye fatigue and reduce decision-making performance [11]. In the CCTV operator room studied, light reflections from the production area onto the monitor screen were found to be one of the causes of visual disturbance. On the other hand, work sampling results showed that the proportion of operator idle time was quite high, and effective focus time was only in the range of 8–10 minutes. The main issues include static posture, visual fatigue, thermal discomfort, lighting glare, limited focus duration, and non-ergonomic workstation design, all of which negatively affect CCTV operator performance. These findings reinforce the indication that suboptimal ergonomic factors contribute to a decline in the visual and cognitive focus capacity of operators.

Although many ergonomic studies have been conducted on office workers and computer operators, research related to CCTV operators is still relatively limited, especially those that simultaneously integrate posture analysis, work activity patterns, and environmental conditions. Most previous studies have only examined one aspect of ergonomics, such as lighting or musculoskeletal complaints, without linking these findings to the overall performance of operators, including their ability to focus, percentage of productive time, and allowance requirements. This research gap highlights the need for comprehensive, evidence-based ergonomic studies to understand how various ergonomic factors interact to influence CCTV operator performance.

This study applies a combined approach that includes work sampling to analyze operator productivity patterns [12], postural analysis using the REBA method to objectively assess musculoskeletal risk [13], [14], [15], as well as evaluating the work environment based on national regulatory standards. This multidimensional approach is expected to provide a comprehensive picture of the working conditions of CCTV operators and the ergonomic factors that most influence their performance. The novelty of this research lies in the integration of these three approaches in the context of visual monitoring work, which has not been widely studied before. Thus, this research not only contributes theoretically to the development of ergonomics, but also offers practical recommendations that can be directly applied to improve the comfort, health, and work effectiveness of CCTV operators.

RESEARCH METHODS

This research methodology was designed to evaluate CCTV operators' work performance through a comprehensive ergonomics approach. The study was conducted directly in the server room where operators perform monitoring activities. Data collection focused on key aspects that influence performance, namely work activity patterns, working posture, and work environment conditions. An ergonomics approach was used because monitoring activities are static and require continuous visual attention, potentially leading to physical and cognitive fatigue if the work system is not well designed.

The data collection technique involved several analytical methods. First, work sampling was conducted at 25 observation points to identify the proportion of productive and unproductive time during operator work. This data was used to calculate the idle ratio, the normal idle time requirements, and the allowance required to maintain optimal operator performance. Next, a rating factor assessment was conducted based on the variables of skill, effort, working conditions, and operator consistency to obtain an objective picture of the operator's workload and focus level. This analysis serves as the basis for determining micro-break needs appropriate to the job's characteristics.

In addition, the methodology is supplemented with body posture analysis using the REBA method and work environment evaluation. Measurements of the angles of each body segment—neck, back, arms, wrists, and lower extremities are taken to determine the level of musculoskeletal risk during monitoring.

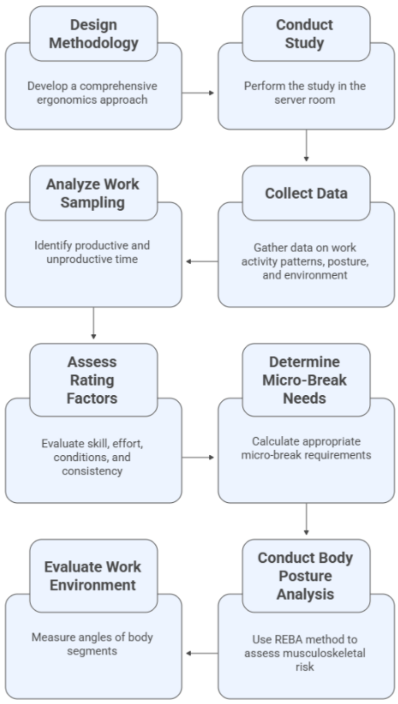

Figure 1. Research Flow

The research flow in Figure 1 illustrates a series of activities starting from the identification of ergonomic problems in the CCTV operator's workspace, which includes static work posture, environmental conditions, and activity patterns during the monitoring process. Once the problems were

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defined, the research continued with the design of data collection methods consisting of work sampling to obtain the proportion of productive time and break time, work posture analysis using the REBA method to assess the level of musculoskeletal risk, and measurement of environmental parameters such as temperature, air velocity, visibility, and light intensity. All collected data was then systematically processed and analyzed to assess the relationship between ergonomic factors and operator performance.

RESULTS AND DISCUSSION

1. Human-Computer Interaction and Working Conditions

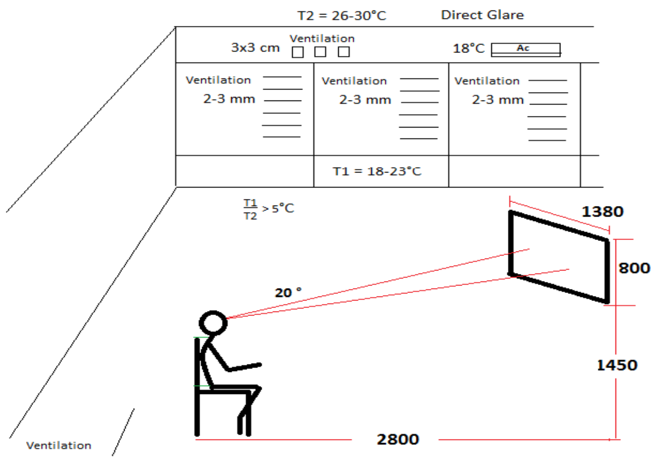

Figure 2. Workstaion Operator CCTV

Figure 2 illustrates the outdoor temperature range of 26-30°C and the indoor air conditioner set at 18°C. In the CCTV operator's workroom, there is a 2-3 mm ventilation opening in the west window and a 3x3 cm ventilation above the window, with a relative air speed/movement from outside to inside the room of 0.5 m/s. Therefore, the temperature in the workroom during the day is within the comfortable working range, which is between 23-26°C. Discomfort in the workroom occurs between 9:00 p.m. and 5:30 a.m., when the room temperature is between 18-20°C. The low temperature in the workroom is influenced by the tendency for high environmental humidity, so that at night the room is relatively cold (below normal). Meanwhile, the operator's visual area (eye) distance to the object is 2.8 meters with a visual area viewing angle of 20°, and the object height is 1.45 meters. This causes the operator's neck to tend to tilt backward. The layout can be adjusted by reducing the object height to match the operator's sitting eye height, which is 1.21 meters. Glare occurs due to direct light reflection from the RRC production area onto the object (monitor). Glare on the object area can interfere with the visual area during monitoring. To prevent glare on the object, a transparent black film can be applied to the west-facing windows of the server room.

2. Work Sampling

Work sampling techniques are used to determine the delay/idle ratio, performance level, and standard time of a number of machines, operators, or other work facilities. Work sampling aims to evaluate work systems with the goal of improving work productivity from a human perspective.

No	Bil Rand	Waktu	Produktif		Idle
			Fokus	Durasi (Mnt)	
1	2	7:20	√	28	
2	5	7:50		5	√
3	6	8:00		4	√
4	8	8:20	√	6	
5	9	9:30		3	√
6	10	9:40		4	√
7	12	10:00	√	9	
8	13	10:10		5	√
9	17	10:50		2	√
10	19	11:10		2	√
11	20	11:20	√	15	
12	**22**	**11:40**			
13	**23**	**11:50**			
14	**24**	**12:00**			
15	**25**	**12:10**			
16	**26**	**12:20**			
17	**27**	**12:30**			
18	29	12:50	√	9	
19	30	13:00		6	√
20	32	13:20		4	√
21	35	13:50	√	19	
22	36	14:00		1	√
23	38	14:20	√	17	
24	40	14:40		3	√
25	41	14:50	√	17	
Total			**8**	**159.0**	**11**
Rata-Rata Fokus Pengamatan				**8.37**	

RATIO IDLE			
Aktivitas	**% Aktivitas**	**Ratio Idle**	
		%	**Menit**
Non Produktif	**57.89%**	**1.375**	**82.50**
Produktif	**42.11%**		

Raiting Faktor	
Good Skill (C1)	0.06
Good Effort (C1)	0.05
Average Conditions (E)	0.02
Poor Consistency (F)	0.04
Total 1+RF	1.17
Normal Idle Time (Meni	**15**

Faktor	Pekerjaan	Allowance %
Tenaga Yang Dikeluarkan	Bekerja Dimeja, Duduk	1
Sikap Kerja	Bekerja Duduk, Ringan	1
Gerakan Kerja	Normal	1
Kelelahan Mata	Pandangan Dengan Fokus Berubah rubah	3
Temperatur Kerja	Sedang, 18-22 Celcius	3
Keadaan Atmosfer	Cukup, Terdapat Sirkulasi Udara	2
Keadaan Lingkungan	Bersih, Kebisingan Rendah	1
Total		12
Normal Allowance Time		17

Fig. 2. Work Sampling

Figure 2 shows that human interaction with computers is a static work process (cognitive, situational factors, isometric muscle contraction), so that work fatigue tends to occur more quickly. From the results of work sampling analysis, it can be determined how long the operator's productive time is for monitoring, normal idle time, and allowance time. This ensures that the operator does not experience visual fatigue (eye strain) when monitoring and prevents the occurrence of nearsightedness. The operator's productive time for focused monitoring is 8-10 minutes. This is followed by normal idle time, which, according to the Rating Factor, is 15 minutes. The recommended allowance time based on the conditions in the workroom is 17 minutes.

3. Work Posture Results and REBA Assessment

Fig. 3. CCTV Operator Work Position

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Table 1. Body Segment Angles

Body Segment	Segment Angle
Neck	20°
Leg	40°
Back	20°
Wrist	15°
Lower Arm	73°
Upper Arm	33°

Musculoskeletal injuries can be caused by incorrect (unnatural) working postures over long periods of time. The correct working posture according to ergonomic principles when working in a seated position is for the L5/S1 to be at an angle of 90°-120°. The analysis of the working posture of CCTV operators was carried out using the Rapid Entire Body (REBA) Assessment Worksheet:

Table 2. REBA Review Analysis

Analisis, Tinjauan	Keterangan
REBA Assesment Workshet	The results of the work posture analysis using the Rapid Entire Body Assessment (REBA) Worksheet showed a REBA score of 3 with a low risk level (level 1 action, meaning that action/improvement may be necessary).
PMP No. 7 Tahun 1964	(Special Requirements) Seats Must Meet the Following Requirements: 1. Must be sized appropriately for the average Indonesian body type and suitable for the workers who use them. 2. Must provide comfortable seating and prevent muscle strain. 3. Must allow for ease of movement while working. 4. Backrests must be properly adjusted.
UU No. 3 Tahun 1969	(Principles) all buildings used by workers and their equipment must: 1. All workplaces must be arranged and all seating must be arranged in such a way that there is no harmful effect on occupational health.
PMK No. 48 Tahun 2016, Pasal 21	Office ergonomics standards include: Workspace size, Equipment layout, Chairs, Desks, Work posture, Duration, Work corridors, and Manual handling.

The results of the work posture analysis show that CCTV operators work in a static sitting position with various body angles that are not entirely ideal. Observations show that the neck angle reaches 20° with a tendency to look up due to the monitor being positioned too high, at a height of 1.45 meters, while the operator's eye height is at the ideal level of around 1.21 meters. This condition causes a misalignment between the line of sight and the monitor position, triggering tension in the neck and back area. In addition, a back angle of 20°, upper arm angle of 33°, lower arm angle of 73°, and wrist angle of 15° indicate potential discomfort when working for long periods. This posture pattern shows that operators tend to adjust their bodies to the position of the equipment, rather than the other way around.

The assessment of musculoskeletal risks using the REBA method showed a score of 3, which is categorized as low risk, but still requires minor improvements to prevent long-term ergonomic disorders. Although the risk is classified as low, this evaluation confirms that neck posture is the most critical aspect due to the non-ergonomic position of the monitor and a viewing distance of 2.8 meters with a viewing angle of approximately 20°. This suboptimal posture, if sustained, can increase visual and neck muscle strain, thereby reducing operator comfort and focus during monitoring activities. Overall, these results emphasize that equipment adjustments, particularly monitor height and workstation layout, are necessary to ensure operator work posture better supports performance and occupational health.

4. Work Environment Evaluation

A. Room Temperature

The room temperature evaluation shows significant thermal differences between day and night in the CCTV operator room. During the day, the temperature ranges from 23–26°C, which is still in accordance with the thermal comfort standards as stipulated in Permenaker No. 13 of 2011. These conditions are relatively conducive to operator comfort because the temperature is within a range that maintains physiological stability without causing heat stress or excessive cold [16]. However, the air conditioning setting at 18°C results in a fairly drastic drop in temperature at night, bringing the room temperature to a range of 18–20°C. This range is below the comfort standard and has the potential to cause thermal discomfort in the form of coldness, muscle tension, and decreased physical flexibility, especially in static work with minimal body movement.

Thermal discomfort at night not only affects the physical condition of operators, but can also affect cognitive performance and focus endurance during monitoring activities [17]. Excessively low temperatures tend to increase the body's thermoregulatory load, requiring more energy to maintain a stable internal temperature. This can reduce work efficiency, increase drowsiness, and accelerate fatigue, especially considering that CCTV monitoring is a repetitive task that requires sustained visual concentration. Therefore, adjusting room temperature at night is an important aspect of creating an ergonomic work environment that supports optimal operator performance.

5. Lighting and Glare

An evaluation of lighting conditions in the CCTV operator room shows that visual quality during the monitoring process is affected by glare or light reflections on the monitor surface. This glare comes from light from the production area that enters the server room and reflects off the screen, thereby interfering with the clarity of the visual display that should be observed by the operator. The presence of glare not only reduces visibility, but also increases the workload on the eyes as operators must make additional efforts to adjust their focus to the disturbed display. In activities that are highly dependent on visual observation, such as CCTV monitoring, this type of disturbance can reduce detection accuracy, slow down response times, and increase the risk of missing important information.

The long-term effects of glare can also potentially accelerate eye fatigue, especially when operators must maintain visual attention during long working hours. Increased visual load can affect cognitive focus endurance and disrupt overall work comfort [18]. To address this issue, one recommended solution is to install transparent black window film on the west-facing windows of the server room. This solution is considered effective in reducing the entry of external light that causes glare, thereby providing more stable lighting conditions that meet the visual needs of operators. With proper lighting control, observation quality can be improved and the risk of visual fatigue minimized.

CONCLUSION

The results of the ergonomic evaluation of CCTV operators show that their working posture is still not fully compliant with occupational comfort standards. Although the REBA analysis yielded a score of 3, which falls into the low-risk category, the upward-facing neck posture is an important finding that has the potential to cause muscle fatigue if left unaddressed for a long period of time. This condition is mainly caused by the monitor being placed too high, which is not in line with the operator's line of sight. Adjusting the height of the monitor is one of the main steps that needs to be taken to improve overall work posture. In addition to posture, the results of the study also show that working conditions have a significant contribution to CCTV operator performance. The room temperature during the day is within the comfortable range of 23–26°C, but at night it drops to 18–20°C, which is below the comfort limit recommended by national regulations. These conditions have the potential to reduce the thermal comfort of operators, especially since monitoring activities are carried out for long periods of time and are static in nature. This discomfort can affect concentration and work effectiveness.

Evaluation of lighting and glare potential shows that light reflections from the production area hit the monitor, thereby interfering with the operator's visual quality. Visual disturbances such as this can increase visual load, accelerate eye fatigue, and reduce the operator's ability to make accurate observations. Factors such as viewing distance, monitor height, and suboptimal lighting contribute to increased visual load, thereby reducing the operator's focus sharpness during monitoring activities. Overall, this study concludes that CCTV operator performance is influenced by a combination of posture, visual load, and working environment conditions. The operator's focus time, which only reaches 8–10 minutes, accompanied by a normal idle time requirement of 15 minutes and an allowance of 17 minutes, shows that monitoring work is demanding and requires proper rest arrangements. Therefore, ergonomic improvements through workstation rearrangement, temperature control, and glare control are important recommendations for improving operator comfort and work effectiveness in a sustainable manner.

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