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Ergonomics Intervention at Conservation Tourism Trekking Activities to Decrease Tourists' Risk of Fatigue and Musculoskeletal Disorders (MSDs)

I Ketut Gde Juli Suarbawa[1], M. Yusuf[2], Lilik Sudiajeng[3]
[1, 2]*Mechanical Design Engineering Study Program, Bali State Polytechnic*
[3]*Civil Engineering Study Program, Bali State Polytechnic*

Abstract: ***Tourists aim to derive satisfaction and comfort when traveling, although they may experience fatigue. Satisfaction and fatigue are not always correlated, as individuals may feel tired but satisfied and comfortable on a trip. Therefore, the quality of tourism can be improved through the application of ergonomics to reduce fatigue and risk of musculoskeletal disorders. The first phase of this research was conducted on 100 participants who met the inclusion criteria and expressed willingness to serve as the control group. Trekking activities during phase one were carried out according to established procedures without any ergonomics intervention. The second phase was conducted on 100 participants who met the inclusion criteria and showed willingness to be part of the treatment group. The results showed ergonomics intervention in the form of implementing a short break of 3 minutes every 1 hour, providing information in the form of occupational health and safety (OHS) signs relating to danger warnings, evacuation routes, warnings, and prohibitions along trekking route, had an effect on reducing workload during trekking activities. This intervention also significantly reduced fatigue and musculoskeletal disorders.***
Keywords: ergonomics intervention, workload, fatigue, and musculoskeletal disorders

I. INTRODUCTION

There are two trekking routes in Munduk Village conservation tourism area, namely through Subak Dayang and Subak Lampah. Each route covers approximately 4 km and requires about 4 hours to complete, passing three waterfalls, namely Melanting, Labuhan Kebo, and Red Coral. Trekking tourism is related to the perception of destination safety risk, as well as the suitability of the climate, which contributes to the destination's image [1]. Moreover, tourism sector has various risks, including fatigue or physical injury from strenuous and dangerous activities, psychological risk, as well as other negative impacts [2]. Several individuals perceive risks differently, with higher perception influencing travel decisions [3]. Engaging in activities for a duration of 4 hours can lead to musculoskeletal injury, a cumulative disorder characterized by discomfort and pain, resulting in reduced physical capabilities and productivity [4].

Tourists' pursuit of satisfaction and comfort is crucial in tourism. Satisfaction and fatigue are not always correlated, as tourists may feel tired but satisfied and comfortable. Improving tourism quality requires creative methods to minimize "fatigue" while maximizing "satisfaction", which is crucial for the success of the sector, specifically in a competitive landscape [5]. Tourists' fatigue is a common but complex condition characterized by decreased physical function, motivation, emotions, and cognitive abilities [6]. Alzahrani (2019) found a positive relationship between ergonomics and job satisfaction [7], recommending proactive measures through Design Ergonomics [8]. The application of ergonomics provides a fit between people and their work, ensuring tools, information, tasks, and environments are suitable for humans, [7], considering performance abilities and capacities [9]. To address ergonomics issues related to human work activities, the following methods should be used [10], namely (a) Identify current and potential musculoskeletal disorders and related factors through workplace analysis, (b) Define the problem as well as establish what is most prioritized in reducing the identified musculoskeletal disorders, (c) Gather information through observation, video recordings, checklists, direct interviews, and documentation analysis, (d) Assess the problem, (e) Control problems by implementing ergonomics intervention programs such as workstation redesign, changes in work methods, and training, (f) Installation of up-to-date systems.

Previous research on developing tourists' villages through Kansai Engineering method showed that MEAD concept integrated existing components by formulating and establishing a vision & mission, as well as orders or work directions, and Standard Operating Procedures (SOPs).

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This method can help improve the preservation of local wisdom, empower the community, and foster progress in accordance with the village's character [11]. While good product design may suffice for tourism object managers, it is sufficient for tourists, necessitating the integration of health and safety experience with tourism product design [12]. Investigations on waterfalls in Gianyar, Bali, descriptively showed that tourists often experienced accidents such as slipping due to the lack of signs and non-compliance with established standards by the management [13]. Efforts to improve tourism quality by reducing fatigue and risk of musculoskeletal disorders can be carried out through the application of ergonomics. According to Singh, A., & Singh, VK (2022), risk assessment and control positively correlated with Employees retention and efficiency [14]. Ergonomics intervention that successfully reduced agricultural [4] musculoskeletal disorders and poor posture can increase mental workload [15], increase risk perception and adoption of health behaviors, and promote a safe work environment [16], boosting general productivity [17] and job satisfaction [18].

Ergonomics in tourism trekking activities can be applied by (a) implementing a short break of 3 minutes every 1 hour of the journey, accompanied by a brief story about the surrounding natural environment during the break, and (b) providing information in the form of occupational health and safety (OHS) signs relating to danger warnings, evacuation routes, advisories and prohibitions. These measures aim to assess the reduction in fatigue and musculoskeletal disorders after implementing ergonomics in trekking activities. The hypothesis states that there are differences in fatigue and musculoskeletal disorders after applying ergonomics to trekking activities. The current research offered efforts to reduce complaints of fatigue and musculoskeletal disorders, as well as increased tourists' satisfaction in Munduk Village, Bali.

II. LITERATURE REVIEW

A. *Ergonomics Approach in Tourists Destinations*

Ergonomics approach to tourism activities aims to modify the work environment, thereby improving working conditions, organization issues [19], and practices to reduce musculoskeletal disorders and fatigue [20]. Ergonomics (human factors engineering) approach to improving human performance [21] is related to various aspects, namely (1) Nutritional/energy needs [22], (2) Muscle power, including biomechanics, (3) Body posture/physiology, (4) Social/sociological conditions [23], (5) Work environment [24], (6) Working and rest time conditions [25] [26], (7) Information/interaction conditions of humans with visual displays [27], and (8) Human-machine interaction as a medium of transmission and exchange of information between workers and equipment [28].

B. *Potential Dangers of Trekking Activities*

Trekking activities, which are outdoor pursuits aimed at enjoying the panorama of nature and the environment over an extended and challenging period, can be carried out by anyone on foot with the aim of exploring nature for fun [29]. However, as trekking activities increase, tourists are often unaware of or unprepared for potential dangers. Factors such as lack of regulations and insufficient knowledge about disaster response can pose significant threat to tourists' safety [30]. The hazards associated with trekking activities often originate from continuous activities, including repetitive physical exertion, which can lead to fatigue or musculoskeletal disorders. To address these challenges, effective danger risk management is essential in tourism, as tourists may not always be adequately prepared to confront risk or hazard [31]. Engaging in outdoor recreational activities may increase the probability of encountering negative risk [32].

C. *Complaints of Fatigue*

Trekking is a physical activity that is carried out continuously, leading to fatigue as well as longer reaction times, reduced alertness, impaired memory, and impaired judgment, thereby decreasing occupational health [33]. Fatigue can be classified as follows [34]: (a). Physical fatigue, characterized by a significant decrease in mobility ability toward the end of the workday; (b). Mental fatigue, representing a decline in cognitive work ability toward the end of the work period; (c). Emotional labour burnout, reflecting a decrease in emotional activity toward the end of the workday.

D. *Musculoskeletal Disorders*

Musculoskeletal disorders refer to the onset of mild to very painful sensations in parts of the skeletal muscles experienced by individuals as a result of certain activities [35]. Continuous static work over extended periods can lead to damage in muscles, nerves, joints, ligaments, and tendons, resulting in complaints related to injuries in the skeletal muscle system, commonly known as musculoskeletal. disorders [36]. Musculoskeletal disorders can also originate from psychological mechanisms that induce stress, leading to muscle tension.

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Increased psychological demands can amplify physical work demands and symptoms of musculoskeletal complaints [37]. These disorders are often associated with workplace conditions, characterized by repetitive movements over prolonged periods coupled with ergonomics work attitudes. Trekking as an activity of walking for extended periods, is often accompanied by unnatural body postures.

III. METHODS

A. Research Sites

This research used a quantitative method, specifically a quasi-experimental two-group pre-test post-test control group design. The aim was to determine the effect of an intervention on an experimental group. This design offered a means of comparison between the two groups. Furthermore, it was conducted from July to September 2023 at the Munduk Village Trekking Tour, Banjar District, Buleleng Regency, passing three waterfalls, namely Melanting, Labuhan Kebo, and Red Coral.

B. Research Subject / Participants

The subjects were determined based on the following criteria: (a). Age range of 20-56 (b). Possessing a normal physique and ability to work without being hindered by physical limitations (c). Expressing willingness to participate as research subjects. Since the exact number of visiting tourists could not be determined, a Non-probability Sampling method was used [38] within the field of case-control research [39]. Accordingly, the sampled population should meet the specified criteria. The sampling technique used was Accidental Sampling [38] or convenience sampling with limited external validity [40]. Based on this method, the sample selection depended on the coincidence of meeting the research team. The sample size was calculated using the Slovin formula [41] due to the unlimited population.

$$\text{Number of sample (n)} = \frac{Z\ 2}{4\ (Moe)\ 2}$$

Information:

n : Number of Sample

Z : the z score value is 1.96 [42]

Moe : margin error value of 0.1 (10%) [42]

$$\text{Number of sample (n)} = \frac{(1.96)\ 2}{4(0,1)\ 2} = 96.04 \text{ people (rounded to 100 people)}$$

C. Research Design

This is a short case research with a two-group pre-test and post-test design [43], which was observationally conducted on tourists engaging in trekking activities in Munduk Village conservation tourism area, as shown in Figure 1.

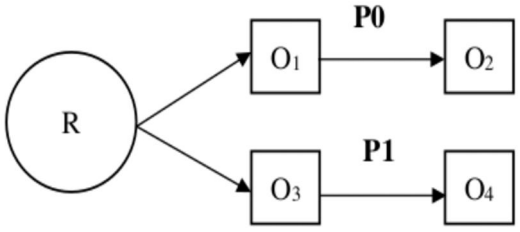


Figure 1. Research Design [43]

Information

R = Randomly selected sample.

P0 = Phase 1 research

P1 = Phase 2 research

O 1, O 3 = Units of measurement before trekking activities.

O 2, O 4 = Units of measurement after trekking activities.

D. Tasks and Assessment

Phase one research (P0) was conducted on 100 participants who met the inclusion criteria and expressed willingness to participate. Trekking activities were carried out according to established procedures without any ergonomics intervention. Phase two (P1) also included 100 participants who met the inclusion criteria and expressed willingness to participate. Trekking activities were carried out according to predetermined procedures and were accompanied by ergonomics intervention. This included implementing a short break of 3 minutes every hour of travel time and providing information/displays in the form of occupational health and safety (OHS) signs relating to danger warnings, evacuation routes, as well as warnings and prohibitions along trekking route. During the 3-minute breaks, participants were encouraged to relax and recover, and the tour guide provided a brief narrative about the surrounding natural environment.

Before commencing trekking activities in both phases, all participants had resting pulse recorded and completed musculoskeletal disorders and fatigue complaint questionnaires, assisted by the research team. The pulse rates were recorded every hour during trekking. After reaching the finish line, participants recorded recovery pulse rates and completed musculoskeletal disorders and fatigue complaint questionnaires, assisted by the research team. Musculoskeletal disorders were assessed using the Nordic Body Map questionnaire [44], while fatigue was evaluated using the EORTC Core questionnaire Quality of Life (EORTC QLQ-C30), designed to measure physical, psychological, and social functioning through multi-item and single-item scales [45]. After participating in the research activities, all participants received an appreciation note along with a souvenir, namely a 100-gram of locally sourced coffee powder from Tamblingan.

E. Research Procedure

The variables measured included: (1). Workload for trekking activities recorded from resting pulse (before starting activity) and working pulse (trekking activities recorded every hour); (2). Complaints of fatigue before and after trekking activities; (3). Musculoskeletal disorders before and after trekking activities. The variables were measured both before the implementation of ergonomics (P0) and after the implementation of ergonomics (P1).

F. Data Analysis

Collected data were analyzed through SPSS version 23.0, a statistical tool unraveling the intricate web of relationships among predetermined variables. The data comprising pulse rate, musculoskeletal complaints, and fatigue were meticulously scrutinized as follows: (1) Descriptive analysis showed the essence of the data's characteristics gleaned from research results; (2) The Shapiro-Wilk Test evaluated normality across all research data sets with a sample size less than 50; (3) Data comparability assessment juxtaposed pre-treatment (O1 and O3) and post-treatment (O2 and O4) average values; (4) Group data with a normal distribution underwent scrutiny through the Independent Sample Test; (5) Non-normally distributed data underwent transformation, and Wilcoxon Sign Ranks Test was conducted when normality was not achieved; (6) Treatment effect test, namely testing the difference in mean data after receiving treatment (O2 and O4); (7) A consistent significance level of 5% (α=0.05) showed the validity of all statistical examinations.

IV. RESULTS AND DISCUSSION

A. Participant Characteristics

This research included 100 participants in the control group (P0) and 100 in the treatment group (P1). The participants were tourists engaging in trekking activities from July to September 2023 at the Munduk Village Trekking Tour. The age range of those in the control group (P0) was between 24 and 55 years, with an average of 41.71 $\pm$ 9.95 years. The age for the treatment group (P1) ranged from 23 to 58 years, with an average of 41.91 $\pm$ 8.23 years. These ages fell within the working-age cohort and met the criteria for the labour force category as per BPS guidelines. The defined age range for Indonesia's labour force spans from 15 to 64 years, as mandated by the relevant legislation. The age range was consistent with musculoskeletal disorders research in fresh fruit bunch (FFB) harvesting processes with an average age of 25.4 $\pm$ 4.33 years [46], musculoskeletal disorders research in industrial workers comprising respondents aged 37 ± 8 years [47], and work posture research on truck manufacturing factory operators, with an average of 42.0 ± 7.6 years [48]. Trekking experience of participants in the control group (P0) was between 1-5 years with an average of 3.52 $\pm$ 1.38 years. Trekking experience of the treatment group (P1) participants was between 1-6 years, with an average of 3.27 $\pm$ 1.50 years. Further details are presented in Table 1.

Table 1. Descriptive statistics characteristics of control group (P0) and treatment group (P1) participants

Variables	Group	Descriptive Statistics				
		N	Mean	Minimum	Maximum	Standard Deviation
Participant Age	Control group (P0)	100	41.71	24.00	55.00	7.95
	Treatment group (P1)	100	41.91	23.00	58.00	8.23
Trekking experience	Control group (P0)	100	3.52	1.00	5.00	1.38
	Treatment group (P1)	100	3.27	1.00	6.00	1.50

N: Number of participants

B. Trekking Activities Workload

Workload was assessed by measuring heart rate before and during trekking activities. The results showed that the average resting pulse rate of participants in the control group (P0) before trekking activities was 72.30 ± 3.99 beats/minute, with a minimum value of 64.00 beats/minute and a maximum of 78 beats/minute. In contrast, the average resting pulse rate of participants in the treatment group (P1) was 74.28 ± 5.12 beats/minute, with a minimum value of 64.00 beats/minute and a maximum of 80 beats/minute. The average pulse rate during trekking activities measured every hour in the control group (P0) was 114.57 ± 2.46 beats/minute, with a minimum of 108 beats/minute and a maximum of 122.00 beats/minute. Conversely, the average pulse rate during trekking activities in the treatment group (P1) was 107.73 ± 2.68 beats/minute, with a minimum of 96.00 beats/minute and a maximum 114.00 beats/minute. Further details are presented in Table 3.

Table 3. Descriptive statistics resting pulse rate and pulse rate during trekking activities of control group (P0) and treatment group (P1) participants

Variables	Group	Descriptive Statistics				
		N	Mean	Minimum	Maximum	Standard Deviation
Resting pulse before trekking activities	Control group (P0)	100	72.30	64.00	78.00	3.99
	Treatment group (P1)	100	74.28	64.00	80.00	5.12
The pulse of trekking activity	Control group (P0)	100	114.57	108.00	122.00	2.46
	Treatment group (P1)	100	107.73	96.00	114.00	2.68

N: Number of participants

The average pulse rate during trekking activities for the control group (P0) was 114.57 ± 2.46 beats/minute, while the average pulse rate for the treatment group (P1) was 107.73 ± 2.68 beats/minute, showing a difference in heart rate. The pulse of participants in the treatment group (P1) was lower than that of the control group (P0). Therefore, the treatment effect of applying ergonomics to trekking activities could reduce workload (activities pulse) by 5.97%. Kolmogorov-Smirnov test results for resting pulse rate before and during trekking activities and pulse rate in both the control group (P0) and treatment group (P1) were ($p > 0.05$), showing normal distribution of data. Independent sample test showed that the average resting pulse rate before trekking activities between the control group (P0) and the treatment group (P1) was not significantly different, ($p > 0.05$), with similar influence in both groups. However, the independent sample test for the average pulse rate showed a significant difference between the control group (P0) and treatment group (P1) ($p < 0.05$). The treatment effect of applying ergonomics to the treatment group's trekking activities influenced a reduction in workload during activities. Several research provided evidence regarding the effectiveness of alternative approaches to ergonomics intervention, such as process-oriented ergonomics, which could address some of the more complex aspects of human-machine-environment interactions [49]. This was consistent with research showing a relationship between physical tasks, cognitive, manual control, and time pressure, and the subjective burden experienced by an operator [50]. The results of the independent sample test are presented in Table 4.

Table 4. Kolmogorov-Smirnov test and independent sample test average resting pulse rate and trekking activities pulse rate of control group (P0) and treatment group (P1) participants

Variables	Group	N	Kolmogorov-Smirnov Test	Independent Sample Test	
			p	t	p
Resting pulse before trekking activities	Control group (P0)	100	0.068	-3,046	0.013
	Treatment group (P1)	100	0.114		
The pulse of trekking activities	Control group (P0)	100	0.110	18,788	0,000
	Treatment group (P1)	100	0.152		

N: Number of participants

C. Complaints of Fatigue

Fatigue complaints were measured based on general fatigue experienced before and after trekking activities. Feelings of fatigue were measured by completing the EORTC Core questionnaire Quality of Life (EORTC QLQ-C30) independently. The results showed that the average fatigue complaint score before trekking activities in the control group (P0) was 31.52 ± 0.99, with a minimum score of 30.00 and a maximum of 33.00. The average fatigue score before trekking activities in the treatment group was 30.60 ± 1.06, with a minimum of 29.00 and a maximum of 32.00. The average fatigue score after trekking activities in the control group (P0) was 45.60 ± - 3.04, with a minimum of 39.00 and a maximum of 51.00. The average fatigue score after trekking activities in the treatment group (P1) was 40.51 ± 2.89, with a minimum of 37.00 and a maximum of 43.00. The increase in fatigue score after trekking activities was 44.67% in the control group (P0) and 32.38% in the treatment group (P1). The results were consistent with research showing that implementing simple, practical improvements applying basic ergonomics principles reduced work-related risk [51] [52]. Fatigue complaint scores are presented in Table 5.

Table 5. Descriptive statistics on fatigue scores before and after trekking activities of control group (P0) and treatment group (P1) participants

Variables	Group	Descriptive Statistics				
		N	Mean	Minimum	Maximum	Standard Deviation
Fatigue before trekking activities	Control group (P0)	100	31.52	30.00	33.00	0.99
	Treatment group (P1)	100	30.60	29.00	32.00	1.06
Fatigue after trekking activities	Control group (P0)	100	45.60	39.00	51.00	3.04
	Treatment group (P1)	100	40.51	37.00	43.00	2.89

Kolmogorov-Smirnov results for fatigue complaint before trekking activities in both the control group (P0) and treatment group (P1) were p >0.05, showing normal distribution of data. Independent sample test showed the average fatigue complaint scores before trekking activities between the control group (P0) and the treatment group (P1) were not significantly different (p > 0.05). The average fatigue complaint score before trekking activities had a similar influence on trekking activities in both groups. However, independent sample test for the average complaint score during trekking activities showed a significant difference between the control group (P0) and the treatment group (P1) (p < 0.05). This showed that the treatment effect of applying ergonomics to the treatment group (P1) trekking activities had an influence on reducing fatigue complaint score during trekking activities. The results of the independent sample test are presented in Table 6.

Table 6. Kolmogorov-Smirnov test and independent sample test average score complaints of fatigue before and after trekking activities of control group (P0) and treatment group (P1) participants

Variables	Group	N	Kolmogorov-Smirnov Test	Independent Sample Test	
			p	t	p
Complaint Score Fatigue before trekking activities	Control group (P0)	100	0.410	6,302	0.010
	Treatment group (P1)	100	0.087		
Complaint Score Fatigue after trekking activities	Control group (P0)	100	0.068	4,975	0,000
	Treatment group (P1)	100	0.090		

D. Musculoskeletal Disorders

Musculoskeletal disorders were measured based on the complaints felt by participants before and after trekking activities. Participants' perception of musculoskeletal disorders was measured by completing the Nordic Body Map questionnaires independently. The results showed that musculoskeletal disorders score before trekking activities in the control group (P0) was 29.93 ± 0.75, with a minimum of 29.00 and maximum of 32.00. The average score before trekking activities in the treatment group (P1) was 29.66 ± 1.53, with a minimum of 28.00 and a maximum of 32.00. The average musculoskeletal disorders score after trekking activities in the control group (P0) was 51.87 ± 5.77, with a minimum of 39.00 and a maximum of 66.00. The average score in the treatment group (P1) was 43.34 ± 5.38, with a minimum of 37.00 and a maximum of 61.00. The improvement in musculoskeletal disorders score after trekking activities in the control group (P0) was 73.30% and 46.12% in the treatment group (P1). This increase could be attributed to the repetitive movements and prolonged static postures during trekking activities, leading to muscle tension and increased stress levels [37]. Prolonged static movements can also cause damage to muscles, nerves, joints, ligaments and tendons, contributing to musculoskeletal disorders [53], [54].

Table 7. Descriptive statistics musculoskeletal score disorders before and after trekking activities of control group (P0) and treatment group (P1) participants

Variables	Group	Descriptive Statistics				
		N	Mean	Minimum	Maximum	Standard Deviation
Musculoskeletal scores disorders before trekking activities	Control group (P0)	100	29.93	29.00	32.00	0.75
	Treatment group (P1)	100	29.66	28.00	32.00	1.53
Musculoskeletal scores disorders after trekking activities	Control group (P0)	100	51.87	39.00	66.00	5.77
	Treatment group (P1)	100	43.34	37.00	61.00	5.38

N: Number of participants

Kolmogorov-Smirnov test results for musculoskeletal disorders score before trekking activities in both the control group (P0) and treatment group (P1) were p >0.05, showing normal distribution of data. Independent sample test showed that the average musculoskeletal disorders score before trekking activities between the control group (P0) and the treatment group (P1) was not significantly different (p > 0.05), with both groups having similar influence. Independent sample test for the average musculoskeletal disorders score between the control group (P0) and treatment group (P1) was significantly different (p < 0.05). This showed that the treatment effect of applying ergonomics to the treatment group's trekking activities influenced a reduction in musculoskeletal disorders scores during trekking activities. The results of independent sample test are presented in Table 8.

Table 8. Kolmogorov-Smirnov test and Independent Sample test average musculoskeletal disorders scores before and after trekking activities of control group (P0) and treatment group (P1) participants

Variables	Group	N	Kolmogorov-Smirnov Test	Independent Sample Test	
			p	t	p
Musculoskeletal disorders scores before trekking activities	Control group (P0)	100	0.019	1,580	0.116
	Treatment group (P1)	100	0.176		
Musculoskeletal disorders scores after trekking activities	Control group (P0)	100	0.200	3,205	0.002
	Treatment group (P1)	100	0.514		

N: Number of participants

V. CONCLUSIONS

In conclusion, ergonomics intervention was provided to tourists engaging in trekking activities for 4 hours in Munduk Village Trekking Tour, Banjar District, Buleleng Regency, passing through three waterfalls, namely Melanting, Labuhan Kebo, and Red Coral.

This included implementing short breaks of 3 minutes for relaxation and recovery, providing narratives about the surrounding natural environment every hour during trekking activities, offering information/displays in the form of occupational health and safety (OHS) signs related to danger warnings, evacuation routes, and prohibitions along the route. The intervention had a significant effect on reducing pulse rate during trekking and alleviating fatigue as well as musculoskeletal disorders. Ergonomics strategies aimed to prevent increased fatigue after work by optimizing task duration and training levels [55], and by relating human factors with work systems and environmental conditions to meet human needs, abilities, and limitations [56], [57]. Furthermore, implementing technical and organizational ergonomics intervention could help reduce physical workloads [48], while the application of total ergonomics included designing work systems considering human, environmental, and organizational factors within the production system [58],[59], [60].

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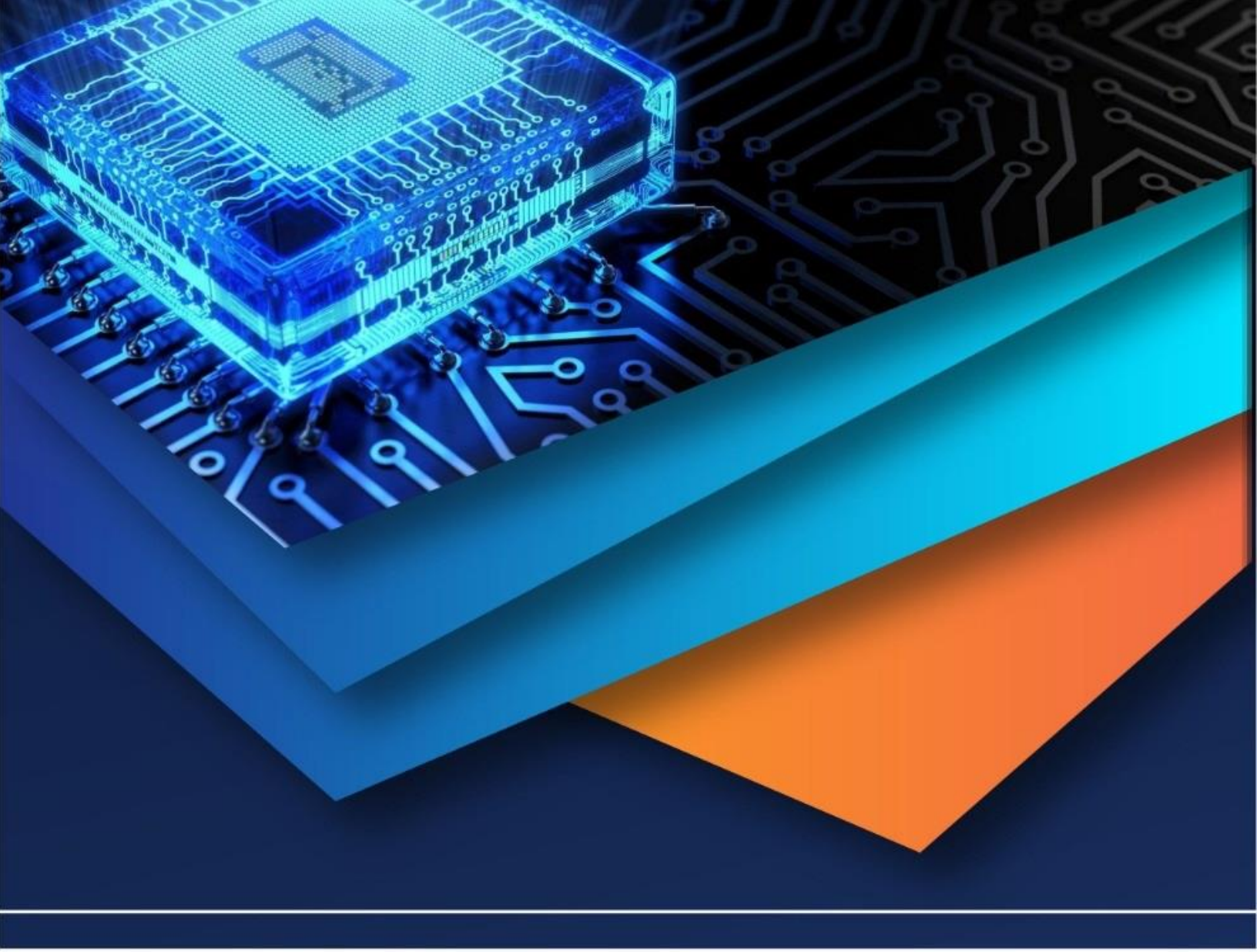
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