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IMPACT OF PROLONGED ORTHOPEDIC SURGICAL DURATION ON COGNITIVE PERFORMANCE AND PHYSICAL WORKLOAD OF OPERATING ROOM TEAM

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Abstract
Background:
In modern healthcare settings, lengthy orthopedic surgical procedures are becoming more common. These procedures can cause significant physical and mental strain in operating room team. These lengthy procedures in such a restricted setting can worsen cognitive function and physical strain, which could affect patient safety and staff well-being as well. This study aimed to determine the impact of prolonged orthopedic surgical duration on cognitive performance and physical workload of operating room team.
Methods:
The operating room team, which includes anesthetists, surgeons, technicians, OT technologists, scrub nurses and circulators participated in a cross-sectional study conducted in operation theatres of Pakistan. The obtained sample size was 145. In order to assess the workload across various lengthy procedures, surgical duration was divided into defined time intervals. Along with all those characteristics, demographic variables like age, years of experience, and professional role were also noted. To evaluate the relationship between surgical duration and workload measures, statistical analysis was carried out using SPSS, by using descriptive statistics and inferential tests, such as correlation and comparison analysis.
Results:
Results of the research showed that extended surgical time durations significantly increased both physical and cognitive strain. Anesthetists had a higher cognitive workload than surgeons and scrub nurses because they had to pay close attention for extended periods of time. Employees with less experience had comparatively higher workload scores than the experienced ones. This study concluded that prolonged orthopedic surgical procedures significantly increase both the cognitive

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and physical workload of operating room personnel. Statistical analysis demonstrated a significant positive correlation between surgical duration and cognitive workload (r = 0.283, p < 0.01) as well as physical workload (r = 0.245, p < 0.01), indicating that longer operations impose greater mental and physical demands on surgeons, anesthesiologists, nurses, technicians, and technologists.

Conclusion:

Prolonged orthopedic surgical procedures have a significant effect on cognitive function and physical burden of operating room team, highlighting the necessity of supporting interventions and efficient workload management techniques.

Introduction

Operating room (OR) teams, comprising surgeons, anesthesiologists, nurses, and technical staff, work in highly demanding environments that require continuous concentration, technical precision, and effective teamwork. According to previous studies, orthopedic procedures are among the most complex and time-consuming surgical interventions, placing considerable physical and cognitive demands on healthcare professionals (1, 2). Prolonged surgical duration contributes to musculoskeletal discomfort, mental fatigue, and reduced work performance, while increasing the risk of intraoperative complications and poorer postoperative outcomes (3, 4, 5). These challenges highlight the importance of understanding how extended orthopedic surgeries affect both the wellbeing of operating room personnel and patient safety.

Fatigue in the operating room consists of both physical and cognitive components. Physical fatigue develops from prolonged standing, repetitive movements, and static postures, whereas cognitive fatigue results from sustained attention, complex decision-making, and continuous problem-solving during lengthy surgical procedures (2, 3). Studies have reported that cognitive fatigue impairs situational awareness, communication, reaction time, judgment, and technical performance, thereby increasing the likelihood of medical errors and compromising patient safety (4, 5, 7, 8). Furthermore, occupational hazards such as sleep deprivation, environmental stressors, and excessive workload further exacerbate fatigue among surgical teams (6, 7).

The operating room environment also plays a significant role in influencing fatigue and surgical performance. Poor ergonomics, workflow interruptions, environmental noise, and ineffective communication increase cognitive workload and physical strain among operating room personnel (9, 10). Conversely, ergonomic improvements, optimized operating room design, effective scheduling, resilience-building strategies, and improved teamwork have been shown to reduce stress and enhance overall surgical efficiency (11, 12, 14, 15). Additionally, technological innovations such as artificial intelligence have demonstrated potential in improving intraoperative decision-making and reducing cognitive workload during prolonged surgical procedures (13).

Although numerous studies have investigated the effects of prolonged surgeries on patient outcomes, surgeon performance, and occupational fatigue, limited research has comprehensively examined the combined physical and cognitive impact on the entire operating room team (2, 4, 9). This gap in the literature underscores the need for integrated research to develop evidence-based interventions that improve staff wellbeing, maintain surgical performance, and enhance patient safety. Strategies including ergonomic optimization, adaptive workload management, intraoperative breaks, resilience training, improved workflow, and flexible scheduling have been recommended to minimize fatigue and promote safer and more efficient orthopedic surgical practice (11, 14, 15, 16, 17, 18).

Literature Review

Rahmani et al. (2025) found that operating room nurses experienced moderate levels of missed perioperative nursing care and mental exhaustion,

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with a significant relationship between fatigue and missed care (19). Pascal et al. (2025) reported that surgeons' physiological factors, including stress, sleep, and physical activity, may influence surgical performance, although current evidence remains limited (20). Boyle et al. (2025) demonstrated that environmental factors, particularly noise, increase cognitive workload and negatively affect surgical performance and patient safety (21). Iris M. Reijmerink et al. (2024) observed that non-muscular fatigue adversely affected surgical performance, especially in simulation-based studies (22). lotaibiet al. (2024) concluded that excessive weekly workload and poor sleep quality significantly increased fatigue among operating room personnel, particularly anesthesia technologists (23).

Amirthanayagan et al. (2024) reported that prolonged standing and high mental workload contribute to musculoskeletal pain, fatigue, and psychological stress among surgeons (24). Pasquer et al. (2024) found that effective operating room organization, stable teams, and proper scheduling improve patient safety and surgical efficiency (25). Palejwala et al. (2023) showed that high operating room temperatures increased perceived workload and fatigue despite having minimal effects on cognitive performance (26). Jalali et al. (2023) demonstrated that occupational fatigue mediates the relationship between mental workload and surgeons' job performance (27). Howie et al. (2023) emphasized that effective cognitive load management improves decision-making and reduces surgical errors (28).

Haney et al. (2023) concluded that robot-assisted surgery improves ergonomics by reducing musculoskeletal strain and physical fatigue among surgeons (29). Shugaba et al. (2022) also reported that robotic surgery imposes lower cognitive and musculoskeletal demands than conventional laparoscopy (30). Armijo et al. (2022) found that female surgeons experience greater muscle activation and fatigue during laparoscopic procedures than male surgeons (31). Pooladgar et al. (2022) demonstrated that sleep deprivation significantly impairs memory and cognitive performance among clinical residents (32). Hotton et al. (2022) and Fan et al. (2022) further confirmed that robot-assisted surgery reduces physical workload and ergonomic strain compared with standard laparoscopic and open surgical techniques (33, 34).

Yousefiazar et al. (2021) reported that perioperative practice temporarily improves attention and concentration among scrub nurses, although these benefits decline with increasing workload and age (35). Behzad et al. (2021) and Chomem et al. (2020) identified poor ergonomics, prolonged work, and inadequate workplace conditions as major contributors to musculoskeletal disorders among operating room personnel (36, 37). Mackenzie et al. (2020) found that distractions and interruptions increase mental workload and reduce team performance and patient safety (38). Armijo et al. (2019), Ward et al. (2021), and Hakim et al., (2018) demonstrated that environmental and ergonomic factors influence physical fatigue and surgical performance, although evidence regarding temperature effects remains inconsistent (39, 40, 41). Yu et al. (2016) and Weigl et al. (2016) concluded that high intraoperative workload and surgical interruptions increase cognitive burden and may adversely affect surgical team performance and patient outcomes (42, 43).

Methodology

This study employed a quantitative cross-sectional research design to evaluate the impact of prolonged orthopedic surgical duration on the cognitive performance and physical workload of operating room (OR) personnel. The research was conducted over a period of 4–6 months among surgeons, anesthesiologists, scrub nurses, technicians, and technologists working in hospital operating rooms. Participants aged 20–45 years, with at least one year of operating room experience and involvement in prolonged surgical procedures, were included, while those above 45 years, with less than one year of experience, diagnosed psychological or physiological disorders, or unwilling to participate were excluded. A non-probability convenience sampling technique was adopted to recruit participants who had direct experience with prolonged orthopedic surgeries.

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The required sample size was calculated using Cochran's formula with a 95% confidence level, an estimated proportion of 0.1, and a 5% margin of error, resulting in a minimum sample size of 138 participants. Although the calculated sample size was 138, a total of 145 completed questionnaires were obtained for the final analysis. Prior to participation, informed consent was obtained from all participants, confidentiality was assured, and personal information was protected throughout the study. The study focused on surgical duration as the independent variable, while cognitive performance and physical workload served as the dependent variables.

The primary outcomes included assessment of cognitive performance, measured through reaction time, attention span, and decision-making ability, and physical workload, assessed through fatigue, exertion, and musculoskeletal strain experienced during prolonged surgeries. Secondary outcomes examined the influence of mental fatigue on cognitive performance, the effects of physical fatigue on daily functioning, and the role of demographic and workplace characteristics such as age, gender, professional role, work experience, and duration of surgery. Data were collected using a structured online questionnaire developed from the NASA-TLX and SURG-TLX instruments, with additional items modified to suit the objectives of the study.

Data were entered, coded, and analyzed using SPSS version 25. Descriptive statistics were used to summarize categorical variables as frequencies and percentages, while Pearson correlation analysis was performed to determine the relationship between prolonged orthopedic surgical duration and the cognitive performance and physical workload of operating room personnel. Statistical significance was established at $p \leq 0.05$ with a 95% confidence interval, and findings were presented using tables and figures. Ethical principles were maintained by ensuring voluntary participation, confidentiality, the right to withdraw without penalty, institutional ethical approval, and unbiased reporting of study findings

RESULTS

Frequency Analysis

There were 145 participants in the study with no missing data. The analysis revealed that most of the participants were within the lowest age group and not much variation existed in the age distribution. Gender distribution was more frequent in one category than in others. In the same way, one category dominated the professional role. The majority of participants reported a mid-range level of operating room experience with a moderate variation in responses. On the whole, the sample was not missing much data and had a fairly concentrated distribution across important demographic variables.

Table 1. Illustrating the statistical analysis for all variables

Statistics

		Age group	Gender	Professional role	Years of experience in operating room	Average duration of surgeries you assist (most common)
N	Valid	145	145	145	145	145
	Missing	0	0	0	0	0
Mean		1.26		3.57		
Median		1.00		3.00		
Mode		1		3		
Std. Deviation		.724		1.195		
Variance		.525		1.428		

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Frequency Analysis with respect to each variable

Age group

The study included 145 subjects. The largest proportion were in the 20–25 years age group (n = 122, 84.1%). It was followed by 26–30 years (n = 16, 11.0%). 2.1% (n = 3) of the sample were aged 31–35 years and 41–45 years, and 0.7% (n = 1) aged 36–40 years. In general, most participants were in the younger age group (20–25 years), suggesting a predominantly early-career sample.

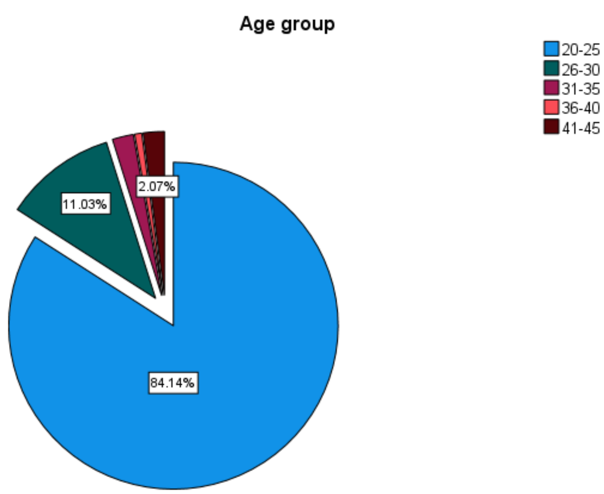
Table 2. Frequency analysis of age groups

Age group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-25	122	84.1	84.1	84.1
	26-30	16	11.0	11.0	95.2
	31-35	3	2.1	2.1	97.2
	36-40	1	.7	.7	97.9
	41-45	3	2.1	2.1	100.0
	Total	145	100.0	100.0	

The pie chart presents the distribution of participants according to age group. The largest group is the age group 20–25 years; it accounts for 84.10% of the sample. The age segment of 26 – 30 years is the second largest segment with percentage of 11.00%. The 31–35 and 41–45 years age groups are each 2.10% and the 36–40 years age group is the smallest segment, accounting for only 0.70%. In general, the pie chart indicates that the majority of the study sample was in the 20–25 years age group.

Figure 1. Frequency pie chart for age groups



Gender

The study had 145 participants. The sample was almost evenly distributed by gender with 73 females (50.30%) and 72 males (49.70%). This indicates equal gender representation in the study population.

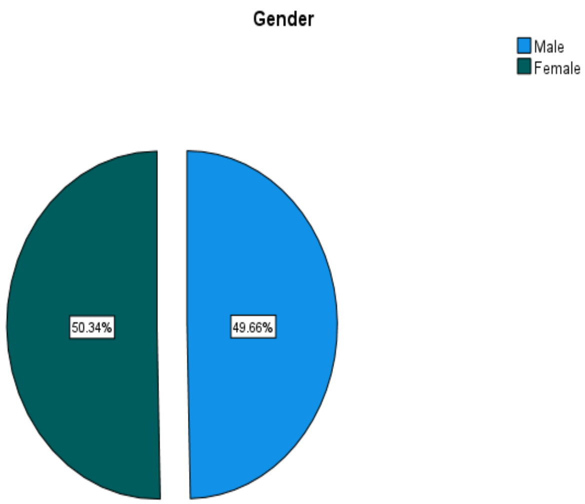
Table 3. Illustrating the frequency analysis of gender

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	72	49.7	49.7	49.7
	Female	73	50.3	50.3	100.0
	Total	145	100.0	100.0	

The pie chart represents the male-female ratio of the participants. The sample was composed of 50.30% female and 49.70% male subjects. The chart shows a near-equal representation of both genders, with a slight predominance of female participants. Overall, the pie chart shows a balanced distribution of gender in study population.

Figure 2. Frequency pie chart of gender



Professional Role

145 people participated in the study. Most were OT Technologists (n = 86, 59.30%), followed by Anaesthesia Technologists (n = 20, 13.80%) and Technicians (n = 20, 13.80%). Anaesthetists and Scrub Nurses (n = 8, 5.50%) were the most common followed by Surgeons (n = 3, 2.10%). The overall sample consisted primarily of OT Technologists

Table 4. Illustrating the frequency analysis of professional role

Professional role

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Surgeon	3	2.1	2.1	2.1
	Anesthetist	8	5.5	5.5	7.6
	OT Technologist	86	59.3	59.3	66.9
	Anesthesia Technologist	20	13.8	13.8	80.7
	Scrub Nurse	8	5.5	5.5	86.2
	Technician	20	13.8	13.8	100.0

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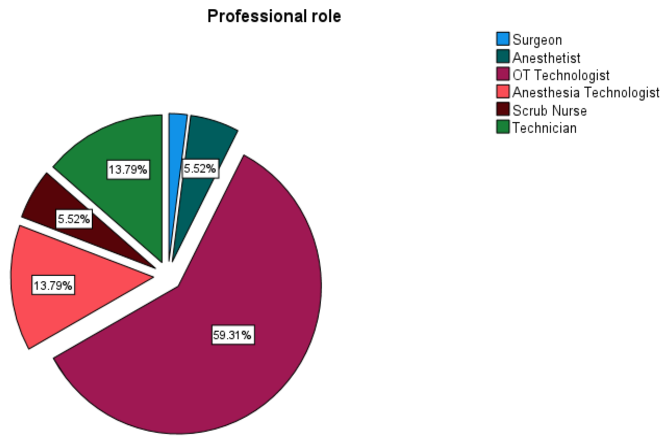
Total	145	100.0	100.0	

The pie chart illustrates the distribution of the participants according to their professional role. The largest group was OT Technologists (59.30%) which implied that they represented more than half of the study sample. The second largest segments were Anesthesia Technologists and Technicians, which accounted for 13.80% of participants each. Anesthetists and Scrub Nurses each made up 5.50% of the total and Surgeons were the smallest group with 2.10%. In general, the pie chart shows OT Technologists were the most common professional group amongst the participants.

Figure 3. Frequency pie chart of professional role



Correlation Analysis

To evaluate the impact of prolonged orthopaedic surgical duration on cognitive performance of operating room team

H0: There is no significant relation between cognitive workload of operating room team and average duration of orthopaedic surgeries.

H1: The average duration of orthopaedic surgeries is significantly related to the cognitive workload of the operating room team.

Level of significance $\alpha = 0.01$

Pearson correlation was applied and the coefficient (r) is 0.283, P-value =0.001. As $p<0.01$, reject the null hypothesis. Thus, statistically, there is a significant positive relationship between surgical duration and cognitive workload.

Table 5. Correlational results for the impact of prolonged orthopedic surgical duration on cognitive performance of operating room team

Correlations			
		CWA	Average duration of surgeries
CWA	Pearson Correlation	1	.283**
	Sig. (2-tailed)		.001
	N	145	145

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Average duration of surgeries	Pearson Correlation	.283**	1
	Sig. (2-tailed)	.001	
	N	145	145
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 5 shows a statistically significant positive correlation between the average length of surgeries assisted and cognitive workload/performance (CWA) of operating room team members (r = 0.283, p = 0.001). This implies that the cognitive workload of the operating room staff increases with the increase in the duration of orthopedic surgeries. However, the weak magnitude of the association indicates a small association between the two variables. The p-value is less than 0.05, thus the result is statistically significant. Overall, the results indicate that longer surgical time has a measurable but moderate effect on increasing the cognitive demands on the operating room team during orthopedic procedures.

To determine the impact of prolonged orthopaedic surgical duration on physical workload of operating room team

H0: There is no significant relation between cognitive workload of operating room team and average duration of orthopaedic surgeries.

H1: The average duration of orthopaedic surgeries is significantly related to the cognitive workload of the operating room team.

Level of significance α = 0.01

Pearson correlation is applied, and the coefficient (r) is 0.245, P-value = 0.003. As, p<0.01, reject the null hypothesis. Thus, statistically, there is a significant positive relationship between surgical duration and physical workload.

Table 6. Correlational results for the impact of prolonged orthopedic surgical duration on physical workload of operating room team.

Correlations			
		Average duration of surgeries	PWA
Average duration of surgeries	Pearson Correlation	1	.283**
	Sig. (2-tailed)		.001
	N	145	145
PWA	Pearson Correlation	.245**	1
	Sig. (2-tailed)	.003	
	N	145	145
**. Correlation is significant at the 0.01 level (2-tailed).			

The Pearson correlation analysis in Table 6 revealed that the mean duration of surgical assistance and the physical workload (PWA) of operating room team members were significantly positively correlated (r=0.245, p=0.003). This suggests that if surgery takes longer, the physical workload experienced by the staff increases. The correlation is weak, however, indicating a low but meaningful association between the variables. The p-value is smaller than .05. Therefore, the result is statistically significant. Overall, the results in total indicate a small increase in physical workload in The present study demonstrated that prolonged duration of orthopedic surgery significantly affects the cognitive and physical workload of operating room team members. There was a positive association between surgical duration and cognitive workload ($r = 0.283$, $p < 0.01$), with longer surgeries being associated with higher mental demands. Likewise, the association with physical workload was large and positive ($r = 0.245$, $p < 0.01$) implying that physical burden increases with longer procedures. Both relationships are weak but consistently show that longer surgical times increase the mental and physical demands on operating room personnel during orthopedic procedures.

In particular, extended surgeries impose a collective cognitive and physical burden on the operating room staff that might result in fatigue and lowered efficiency. The results highlight the need for good workload management strategies, such as staff rotation, scheduled breaks and ergonomic improvements. Fatigue reduction and performance support must also include awareness-raising of healthcare teams and administrators. Conclusion Workload management in long surgical procedures is essential for staff wellbeing, efficiency and safe high quality patient care.

Discussion

The present study demonstrated that prolonged orthopedic surgical duration is significantly associated with increased cognitive workload and physical workload among operating room personnel. These findings are consistent with previous studies showing that longer and more complex surgical procedures increase mental demands, impair attention, and contribute to fatigue, thereby affecting surgical performance and patient safety **(45, 46)**. The results therefore support the study objective that extended surgical duration negatively influences the cognitive performance of operating room staff.

The study also identified a significant positive relationship between prolonged surgical duration operating room personnel during surgical care caused by prolonged orthopedic surgical procedures.

and physical workload, indicating that longer surgeries increase musculoskeletal strain and physical fatigue among operating room personnel. Previous research similarly reported that prolonged standing, repetitive movements, and static postures during surgery contribute to work-related musculoskeletal disorders and physical discomfort among surgeons and nurses **(47, 48)**. Although the correlation was modest, it confirms that surgical duration is an important contributor to physical workload.

The combined effects of cognitive and physical fatigue may reduce productivity, impair decision-making, and increase the likelihood of clinical errors during prolonged orthopedic procedures **(49, 50)**. These findings highlight the importance of implementing fatigue management strategies, including staff rotation, scheduled breaks, ergonomic improvements, cognitive support systems, and regular workload assessment to improve staff wellbeing and patient safety. Overall, the study successfully achieved its objectives by demonstrating that prolonged orthopedic surgical duration significantly affects both the cognitive performance and physical workload of operating room teams.

Conclusion

This study concluded that prolonged orthopedic surgical procedures significantly increase both the cognitive and physical workload of operating room personnel. Statistical analysis demonstrated a significant positive correlation between surgical duration and cognitive workload (**$r = 0.283$, $p < 0.01$**) as well as physical workload (**$r = 0.245$, $p < 0.01$**), indicating that longer operations impose greater mental and physical demands on surgeons, anesthesiologists, nurses, technicians, and technologists. Extended procedures contribute to mental fatigue, reduced concentration, impaired decision-making, musculoskeletal discomfort, and physical exhaustion. These combined effects may adversely influence surgical performance, staff wellbeing, and patient safety. Therefore,

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minimizing fatigue and effectively managing workload during prolonged orthopedic surgeries should be considered a priority for healthcare institutions.

Recommendations

Future research should involve multicenter studies with larger sample sizes and longitudinal or experimental designs to improve the generalizability of findings and establish causal relationships. Researchers should combine subjective assessment tools such as **NASA-TLX** and **SURG-TLX** with objective measures of cognitive performance, including reaction time and error rates. Further studies should evaluate the effectiveness of interventions such as scheduled breaks, staff rotation, ergonomic improvements, workload monitoring systems, and fatigue management programs in reducing cognitive and physical workload. Additionally, future investigations should examine the influence of surgery complexity, teamwork, professional experience, burnout, operating room environment, and different surgical specialties to develop evidence-based strategies that enhance staff wellbeing, surgical efficiency, and patient safety.

Study Limitations

This study has several limitations that should be considered when interpreting the findings. The cross-sectional design limits the ability to establish cause-and-effect relationships between prolonged surgical duration and workload. The relatively small sample size and data collection from a single setting reduce the generalizability of the results to other hospitals and healthcare systems. Furthermore, the use of self-reported questionnaires such as **NASA-TLX** and **SURG-TLX** may introduce response bias. Variations in participants' experience, individual physical capacity, surgical complexity, environmental conditions, previous fatigue, and operating room workflow could also have influenced the results. Therefore, future studies should address these limitations using larger, more diverse populations and objective assessment methods.

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