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Impact of Gaming Skills on Laparoscopic Performance: A Single-Blinded Randomised Controlled Trial

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ABSTRACT

Skills required in laparoscopic surgery are not the natural extend from open surgery. It has been demonstrated that modern video gaming improves the acquisition of these skills. This study aims to evaluate the improvement of virtual laparoscopic performance among house officers' with or without gaming. This single-blinded randomised controlled trial was conducted in Hospital Universiti Sains Malaysia from September 2021 until February 2023. Participants were randomised into control (non-gamer) and intervention (gamer) groups using a stratified block randomisation method. Intervention groups were assigned to structure gaming session using the Nintendo Switch in between laparoscopic simulation. Laparoscopic skills were assessed using laparoscopic cholecystectomy simulation programme. Eleven performance metrics were recorded. Demographic data was analysed using Student's *t*-test and Fisher's Exact Test. Laparoscopic performance results were analysed using repeated measure ANOVA test. A total of 54 house officers were recruited, with a median age of 26 years. Among the 13-performance metrics, the intervention group showed 5/11 metrics significantly improved compared to 3/11 in the control group. Overall performance by total time to complete tasks was significantly improved among the intervention group ($F(2,28) = 7.720$, $P = 0.001$). Path length for both dominant and non-dominant hands improved in the intervention group but not statistically significant. Dexterity assessed by total mistake and total clips wasted significantly better among intervention group ($F(2,28) = 6.924$, $P = 0.002$, $F(2,28) = 4.262$, $P = 0.018$). The study shows modern video gaming skills improve laparoscopic performance, hinting at serious game integration in training, potentially revolutionising clinical education. Gaming might become a prerequisite for laparoscopic surgery trainees, enhancing motivation and engagement alongside traditional simulators.

Keywords: *Video games, Laparoscopic, Cholecystectomy, Simulation training, Virtual*

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INTRODUCTION

In recent years, surgical procedures have changed enormously from conventional open surgery to minimal invasive surgery (MIS) (1). Compared to open surgery, it is known to result in lesser pain, smaller scar, shorter length of hospital stays, and so forth (1, 2). As the primary contributor to MIS, laparoscopic surgery has become a routine practice in most surgical subspecialties. The paradigm shifts of this surgical procedure led to surgical trainees searching for the best training programme and practices.

A few challenges that need to be overcome in laparoscopic surgery include the fulcrum effect, reduced haptic feedback and loss of depth perception, mental reconstruction of 3-dimensional imagery from 2-dimensional images (visual spatial attention), and limited motion range of instruments with complex hand-eye coordination. The difficulties in acquiring these skills lead to a steep learning curve as compared to open surgery (2).

Considering the technical difficulties in laparoscopic surgery, training-hour restrictions, legal issues, and time limitations in real-life surgery, multiple studies have been conducted to look for ways to improve such skills. A commercial laparoscopic simulator, although is known as a "gold standard" tool and has been validated for training purposes, it is very costly and not easily accessible (3–4). This simulator is only able to provide mechanical exercise and the end result is predictable, thus resulting in poor compliance and voluntary engagement. Studies also suggested that simulated surgical training resources may be significantly underutilised potentially due to surgical residents' hectic schedules, time limitations and interest (5). This heightened the focus on simulation platforms or nonsurgical tasks which can translate into surgical settings.

In the context of innovation for surgical skills training, video gaming has attracted the most attention for obvious reasons such as the similarities in manual skill required and screen-mediated task execution. Many previous studies have investigated the association between gaming and laparoscopic surgery. A study showed better psychomotor performance on laparoscopic simulators among undergraduate medical students who had gaming experience in the past; however, there was no significant difference in visuospatial and perceptual abilities (6). Whereas some studies showed better visuomotor control or visual-spatial ability among gamers compared to non-gamers (7, 8).

This study aimed to investigate whether a period of exposure to Nintendo Switch gaming can actually improve the performance of laparoscopic novices on a virtual laparoscopic cholecystectomy via a lap-simulator. Secondary objectives mainly focus on the improvement between dominant and non-dominant hands and dexterity in laparoscopic performance after gaming using Nintendo Switch.

MATERIALS AND METHODS

Consort Diagram

This study was conducted at Universiti Sains Malaysia with 60 house officers from Hospital Universiti Sains Malaysia (HUSM) who volunteered after receiving blanket e-mails. House officers who fulfilled the inclusion criteria, which are those who do not have any laparoscopic experience in the past and with low gaming experience (less than 3 hours a week in the last 10 years), were included in the study. Those house officers who were in surgical posting during recruitment were excluded to prevent subject vulnerability. All participants were randomised using stratified block randomisation with block size of four, stratified according to gender, keeping the number in each group as similar as possible (Figure 1).

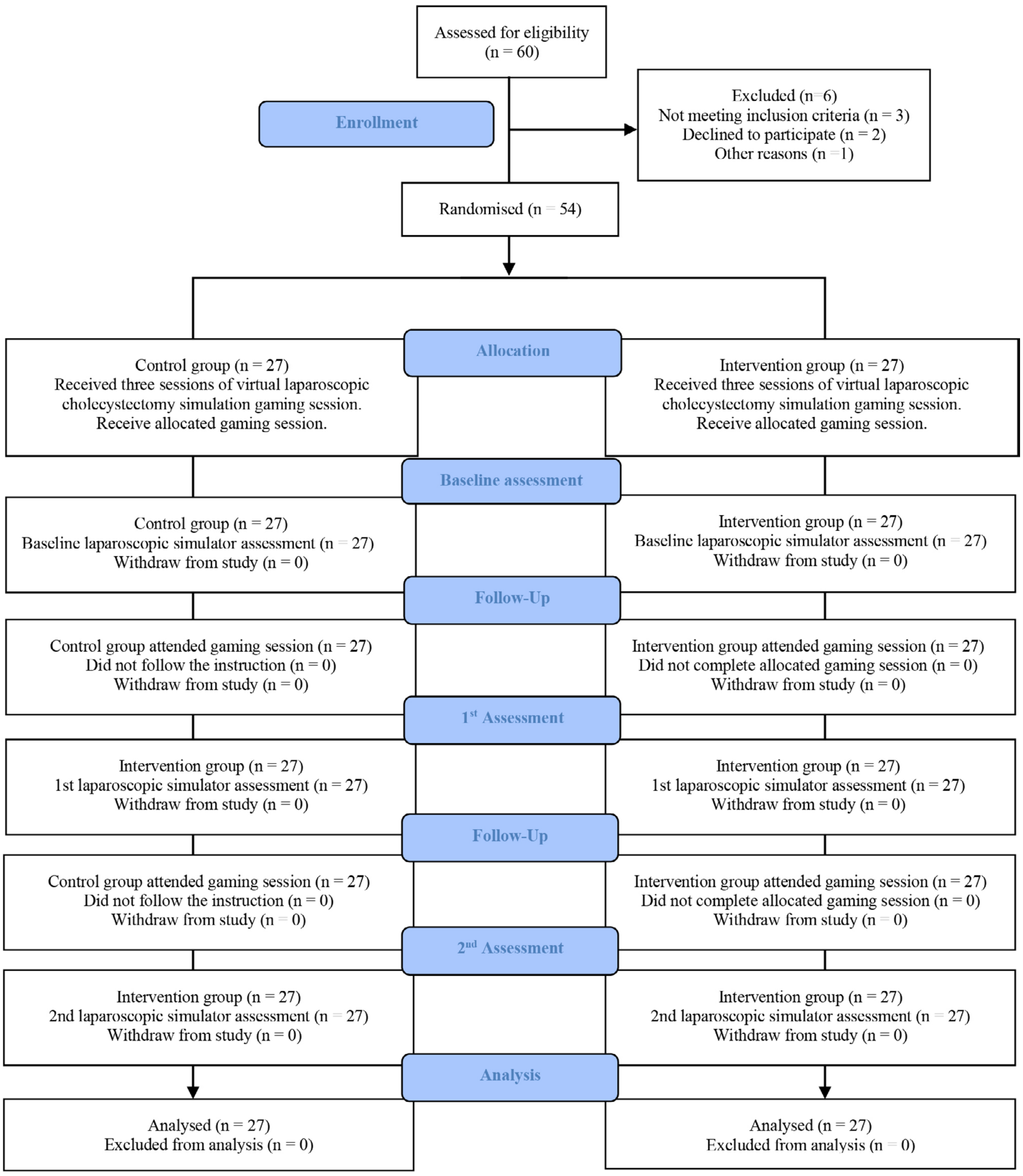

Figure 1: CONSORT diagram.

Research Tools

Study was carried out in USM integrated clinical simulation centre minimal invasive surgery (i-CSC MIS). Figure 1 shows laparoscopic simulator LapVR™ (AE Healthcare, Canada) with built in programme of Laparoscopic cholecystectomy Level II was used as a simulation assessment tool. Level II laparoscopic cholecystectomy simulation required basic laparoscopic skills in combination with basic surgical anatomy of the biliary system to complete the tasks. This programme is able to simulate the fundamentals of laparoscopic surgery manual tasks used in laparoscopic training programmes such as peg transfer and pattern cutting. The LapVR™ also provide haptic feedback on the instrument during the simulation. This allowed the user to corelate with real-life laparoscopic surgery.

The gaming console used was Nintendo Switch (Nintendo, Japan) with a single 2D display and two Joy-Con (controller) for the players (Figure 3). The specification of the Nintendo Switch controller is that it consists of a built-in accelerometer and gyroscope for motion tracking with an infrared sensor for depth tracking to synchronize the Joy-Con with the screen, providing a simulation closest to a 3-dimensional experience for the players. Besides, the Joy-Con is also equipped with the "HD Rumble" engine features, which allow the players to experience haptic feedback during the games. These features add up to have a nearly similar characteristic to a laparoscopic surgery, which allows the participant to acquire the necessary skills required for the laparoscopic simulation performance.

Video games from 1-2-Switch package was selected as the training games (Figure 4). These games were treasure chest, table tennis, baseball, safe crack and ball count. Treasure chests require the players to synchronize the Joy-Con with the treasure chest, which was entangled by the chain, and players need to set loose the chest from the chain. This game trained the players in their hand-eye coordination (HEC). Table tennis and baseball simulate real-life sports, but players need to imagine the ball in a 3-dimensional manner and make sure to synchronise with the Joy-Con to be able to score. Hence, players trained their dexterity skills as well as HEC through these games. For the safe crack and ball count, the games required players to appreciate the vibration provided by the Joy-Con to allow them to complete the task and win the game. These trained the players on the finest tactile sensation which was part of the skill required during laparoscopic surgery.

Figure 2: LapVR™, used with permission by CAE Healthcare.

Figure 3: Nintendo Switch console and Joy-Con.

Figure 4: 1-2-Switch.

Training Programme and Gaming Structure

The Nintendo Switch were installed in the i-CSC along with the laparoscopic simulator. All participants underwent a briefing on the study structure and a demonstration of performing the laparoscopic cholecystectomy simulation on the LapVR™. They were given a session to practice and learn to handle the LapVR™ equipment. This includes the change of instrument within the simulation and electrocautery usage which need to be familiar prior to the actual session. All participants underwent their first session of laparoscopic cholecystectomy simulation and the result was recorded accordingly as the baseline performance. Participants were then randomised into control (laparoscopic session only) and intervention (laparoscopic session with interval gaming session) groups. The intervention group they were exposed to the gaming session in between the laparoscopic assessment. The gaming structure was designed in such a way that each session consists of 5 games with a total of 25 minutes per session. Each participant underwent a total of 24 gaming sessions with different opponents within the intervention group. This makes up a total of 10 hours of gaming exposure in between the laparoscopic simulation session. There was a research assistant supervising the gaming session.

Data Collection

The performance metric for each virtual laparoscopic cholecystectomy simulation was autogenerated by the LapVR™ simulator. Eleven metrics were taken for evaluation which include, the total time to complete a task (mins), the safety of performance (total Blood loss, cc; total Mistake, n/9), dexterity (percentage of critical view of safety visible prior to clipping (%), percentage of tissue covering clots triangle dissected (%), total extra clips used (n), total clips drops (n), total clips wasted (n), the path length of nondominant hand (m), the path length of the dominant hand (m) and proficiency (overall completed tasks, n/8).

Statistical Analysis

Data were entered into the IBM SPSS Statistic version 27 database. Comparisons between groups of demographic characteristics were performed using the Student's *t*-test and Fisher's exact test. The improvement between the two laparoscopic sessions with the baseline was analysed using repeated measure (RM) ANOVA analysis of variance for the repeated measure. The value of alpha was assumed to be 0.05 with a *p*-value less than 0.050 considered to be significant.

RESULTS

A total of 60 house officers received the email for participation in the study; however, six of them were excluded. Three do not meet the inclusion criteria, as two had taken a basic laparoscopic surgical course in the past, and one was a professional gamer. Another three house officers refused to join. A total of 54 house officers were randomised and allotted into the control and intervention groups. All participants completed the given tasks within the time frame and we had zero dropped out during the study periods.

Their age ranges from 25 to 30 years old, with a median age of 26 years old in both groups. The intervention group had a slightly higher number of female house officers compared to the control group. All participants had similar previous gaming experiences, less than three hours per week, prior to the study. Table 1 shows the analysis using Student's *t*-test and Fisher's exact test on the homogeneity of the demographic among the two groups. Both groups show no statistically significant difference between the study groups' demographics.

Table 1: Demographic data of study subjects (Student's *t*-test and Fisher's exact test)

Demographic	Control group (n = 27)	Intervention group (n = 27)	*p*-value
Age, Mean (SD)	26.78 (0.93)	26.85 (1.03)	0.783
Gender, n (SD)			
Male	11 (40.7)	7 (25.9)	0.387
Female	16 (59.3)	20 (74.1)	
Handedness, n (SD)			
Right	23 (85.2)	27 (100.0)	0.111
Left	4 (14.8)	0 (0.0)	
Previous gaming experience, n (SD)			
None 1	15 (55.6)	13 (48.1)	0.816
< 1H/week 2	5 (18.5)	6 (22.2)	
< 3H/week 3	7 (25.9)	8 (29.6)	

Eleven performance metrics were recorded from each laparoscopic cholecystectomy simulation. The intervention group showed improvement in 5 out of 11 metrics analysed, which are statistically significant compared to 3 out of 11 in the control group throughout the 3 sessions of laparoscopic simulation (Table 2).

Table 2: Improvement of performance metrics between control and intervention groups (RM ANOVA)

Task 1 (Lap chole)	**Control group n = 27**					**Intervention group n = 27**				
Performance metric	**Baseline, Mean (SD)**	**Session 1, Mean (SD)**	**Session 2, Mean (SD)**	***F*-value df(2,78)**	***P*-value**	**Baseline, Mean (SD)**	**Session 1, Mean (SD)**	**Session 2, Mean (SD)**	***F*-value df(2,78)**	***P*-value**
Total time to complete task (mins)	10.40 (3.67)	11.24 (3.16)	10.47 (3.32)	0.503	0.607	10.59 (3.69)	9.15 (2.70)	7.58 (1.69)	7.720	0.001*
Safety of performance										
Total blood loss (cc)	16.41 (37.42)	19.70 (41.52)	1.19 (2.68)	2.524	0.087	14.85 (30.46)	7.33 (22.36)	0.59 (1.45)	2.883	0.062
Total mistake (n/9)	1.52 (0.80)	1.41 (0.80)	1.37 (0.49)	0.316	0.73	1.63 (1.21)	1.07 (0.73)	0.74 (0.59)	6.924	0.002*
Dexterity										
Percentage of CVS visible prior to clipping (%)	88.89 (32.03)	100.00 (0.00)	100.00 (0.00)	3.250	0.044*	96.30 (19.25)	100.00 (0.00)	100.00 (0.00)	1.000	0.373
Percentage of tissue covering clots triangle dissected (%)	84.89 (30.98)	93.56 (4.81)	94.70 (3.64)	2.342	0.103	90.81 (19.00)	96.44 (3.72)	97.63 (4.40)	2.723	0.072
Total extra clips used (n)	0.33 (0.62)	0.52 (0.75)	0.22 (0.51)	1.502	0.229	0.33 (0.73)	0.15 (0.46)	0.18 (0.48)	0.794	0.456
Total clips drops (n)	0.67 (1.11)	1.19 (1.21)	0.59 (0.69)	2.658	0.076	1.04 (1.43)	0.41 (0.89)	0.22 (0.80)	4.262	0.018*
Total clips wasted (n)	1.00 (1.41)	1.70 (1.63)	0.81 (0.88)	3.269	0.043*	1.37 (1.64)	0.56 (0.97)	0.41 (0.89)	4.903	0.010*
Path length of non-dominant hand (m)	3.81 (2.13)	4.64 (1.64)	4.76 (1.60)	2.239	0.113	4.35 (2.80)	3.64 (1.73)	3.29 (1.21)	1.906	0.156
Path length of dominant hand (m)	7.76 (3.31)	8.32 (2.51)	8.89 (2.33)	1.151	0.322	7.23 (3.09)	6.70 (2.13)	6.45 (1.67)	0.761	0.471
Proficiency										
Overall completed tasks (n/8)	6.37 (2.59)	7.63 (0.97)	7.93 (0.27)	7.168	0.001*	6.67 (2.30)	7.70 (0.72)	8.00 (0.00)	6.808	0.002*

Note: * significant value; CVS = critical view of safety

Total time taken to complete the task ($F(2,78) = 7.720$, $P = 0.001$) and performance safety represented by total mistake ($F(2,78) = 6.924$, $P = 0.002$) were significantly improved among the intervention group. In the final (2nd) session of the laparoscopic simulation, the control group made almost an extra half of the mistake made by the intervention group (1.37 versus 0.74). The range of time taken to complete the task within the control group was wider compared to those in the intervention group throughout the three sessions. In the intervention group, the range was narrowed down, showing consistent improvement among all the participants. There were few outliers within the intervention group requiring more time than usual to complete the task represented by the dots above the line of upper extreme in the box and whisker plot (Figure 5).

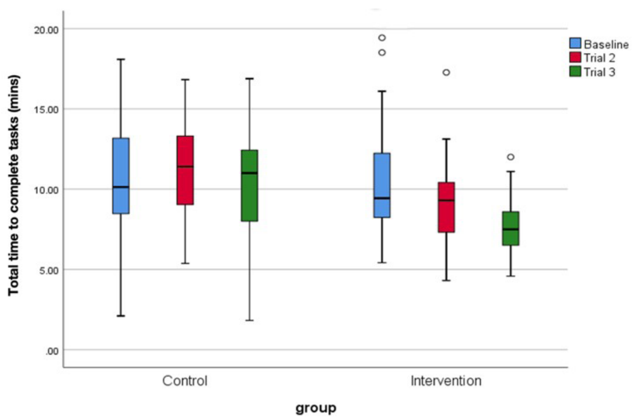

Figure 5: Total time to complete tasks between two groups.

However, subgroup analysis of cumulative blood loss in the performance safety was not statistically significant ($F(2,78) = 2.883$, $P = 0.062$). Statistical analysis on improvement in dexterity was not significant in terms of percentage in critical view of safety (CVS) visibility prior to clipping and percentage of tissue covering clots triangle dissection. Total extra clips used, dropped and wasted during the simulation was significantly improved among both groups but more over the intervention group in term of statistical analysis (1 out of 3 in control group versus 2 out of 3 in intervention group).

From the result, the path length for the dominant hand in the intervention group showed improvement in terms of the shorter travel distance needed to complete the task in the final session compared to the baseline. However, it was statistically not significant ($F(2,78) = 0.761$, $P = 0.471$). Whereas in the control group, the path length for the dominant hand deteriorated in terms of the longer distance required to complete the task, but it was statistically not significant as well ($F(2,78) = 1.151$, $P = 0.322$) (Figure 6). Similar result was observed in the path length for non-dominant hand between the two groups.

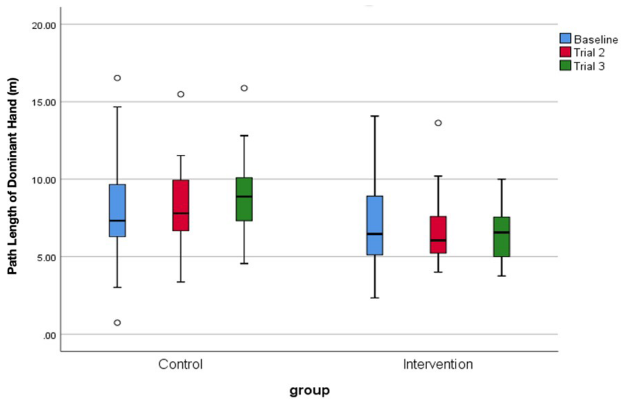

Figure 6: Path length of dominant hand in meters between two groups.

The proficiency of laparoscopic performance is the completeness of steps carried out towards the end of the simulation, and the result showed significant improvement within both groups (Control $F(2,78) = 7.168$, $P = 0.001$; Intervention $F(2,78) = 6.808$, $P = 0.002$).

DISCUSSION

The acquisition of technical skills in surgery, particularly laparoscopic surgery, relies on psychomotor, visuospatial and pictorial depth perception abilities. Traditional methods of surgical training have been deemed insufficient, leading to a shift towards virtual simulated learning (9–11). Regulatory bodies like Society of American Gastrointestinal and Endoscopic surgeons (SAGES) and European Association for Endoscopic Surgery (EAES) have established structured training programmes such as the fundamentals of laparoscopic surgery manual tasks to standardise training globally. However, despite the availability of sophisticated simulators, engagement in training remains low due to various intrinsic and extrinsic factors, with lack of available time being a significant barrier (5, 10, 12). To address these challenges, the surgical community is exploring alternative methods such as serious games, which offer a more engaging and flexible approach to skill acquisition. Studies are being conducted to demonstrate the transfer of skills from gaming to surgical practice, aiming to enhance voluntary engagement and sustainability of training.

In our study, we observed that house officers willingly participated in the gaming sessions and laparoscopic tasks assigned to them, without any dropouts during the study period. This suggests that non-surgical tasks might offer a viable option to increase voluntary engagement in enhancing surgical skills. Based on anecdotal evidence from our research assistant, these sessions were typically scheduled after the participants' working hours, indicating that the workload during the day may hinder surgical skill practice among trainees, despite the availability of facilities like LapVR™ for laparoscopic training. In a study conducted by Chang et al. (13), surgical residents faced time constraints for using the simulator voluntarily during working hours, with only one resident using it on their day off, indicating limited off-time usage as well. It is possible that playing video games at home could offer a more accessible alternative, potentially improving laparoscopic surgery skills.

A previous study showed that undergraduate students can significantly improve their laparoscopic surgical skills over a training period of 10 hours (14, 15). Regardless of their prior gaming skills, they were able to improve their performance over the three trials per task, underlining the fact that laparoscopic performance is a skill that improves with practice (16). Being said that, in our study result, the control group had showed deterioration of the skills rather than improvement despite three trials chance given. Whereas the intervention group that underwent gaming practice using Nintendo Switch in between the laparoscopic task had a more consistent performance and improvement throughout the three trials. This result is in line with a prior study on individuals who played video games in the past and exhibited superior baseline laparoscopic simulator skills compared to non-gamers, including faster completion of laparoscopic tasks (17, 18).

In practical terms, beginners in laparoscopic surgery often demonstrate less activity in their non-dominant hand compared to their dominant hand due to a lack of coordination and voluntary movement, as the focus tends to be primarily on the dominant hand, neglecting the non-dominant one (19). This phenomenon has been observed across various two-handed tasks, particularly those involving screen-mediated execution. Proficiency in these skills is crucial for laparoscopic surgeons, especially when advancing to tasks like suturing and knot tying, which require bimanual coordination and typically entail a steep learning curve (19). This set of skills relates to hand-eye coordination, which is notably enhanced among gamers, as evidenced in one of the studies where gamers showed better scores in endovascular simulations (20). In our study, we utilised path length as the primary parameter to assess the improvement in both dominant and non-dominant hands after the gaming exposure. We observed a significant reduction and narrowing of the path length range among house officers in the intervention group across the three sessions compared to the control group. Although the findings were not statistically significant, the considerable improvement indicates that sufficient gaming practice can indeed impact skill acquisition in both dominant and non-dominant hands.

Video games also contribute to improved visuospatial abilities and pictorial depth perception, essential for interpreting visual clues and navigating three-dimensional spaces. Surgical trainees often utilise video games to familiarise themselves with screen interfaces akin to laparoscopic surgery. Additionally, modern gaming consoles with infrared technology further enhance players' pictorial depth perception, mirroring the skills required in laparoscopic procedures (21, 22). The Nintendo Switch's two-dimensional interface aligns well with the laparoscopic systems commonly found in healthcare facilities (23). When paired with games like table tennis and baseball from the 1-2-Switch package, players can enhance their visuospatial ability and depth perception, thereby improving the overall dexterity needed for laparoscopic surgery (21, 24). With a reasonable time of exposure to these games, house officers in the intervention group had clearly demonstrated improvement in terms of total mistakes performed, which consisted of a total of nine sub-parameters. The clips used also reflect well on dexterity as the steps of applying clips to the cystic duct and cystic artery required a considerable amount of precision. This was shown to be statistically significant among the intervention group in our study.

The Joy-Con controllers of the Nintendo Switch feature a built-in "HD rumble" system, offering users haptic sensations that are almost similar to the kinaesthetic feedback experienced during laparoscopic surgery, akin to the force exerted on tissue. This can be well practice using the games on Safe Cracker and Ball Count given to the participants in the intervention group. A prospective cohort study showed that by adding haptic sensation into the training of laparoscopic tasks on life-like models, tissue manipulation skills improve significantly (25). LapVR™ offers haptic feedback during simulations, but lacks parameters related to the force exerted on surrounding tissue, making it impossible to extrapolate results on the improvement of that skill between the control and intervention groups. Considering the additional vibration (haptic feedback) on the user's instrument, which could potentially lead to increased path length distances, the results indeed indicate longer path lengths among the non-gamer (control) group. This indirectly suggests an advantage in the improvement of the intervention group, who underwent specific gaming practices focused on haptic sensation.

The strengths of this study lie primarily in its prospective exposure of gaming skills among the sample, rather than relying on their previous gaming experiences, thereby eliminating potential confounding factors related to subjective assessments of abilities acquired over a lifetime. The absence of dropouts during the study period indirectly indicates the success of this study design in generating interest among house officers. However, several limitations were identified. While recent advancements in medical device technology have shifted towards 3-dimensional imaging to address limitations such as dexterity and depth perception inherent in 2-dimensional interfaces, this study did not utilise such devices for the laparoscopic simulator or gaming console. With sufficient funding and support, integrating these advancements could enhance the significance of the study. Additionally, the older model laparoscopic simulator, although capable of providing haptic feedback during simulations, lacked data on tactile feedback regarding force exertion on tissue during laparoscopic cholecystectomy simulations, which holds substantial relevance in real-life laparoscopic surgery.

In future investigations, it would be prudent to thoroughly explore the potential correlation between video gaming and robotic surgery, as emerging evidence suggests that these two domains may exhibit even greater similarities in terms of the skills demanded. Expanding our understanding in this area could offer valuable insights into the transferability of gaming proficiencies to the complex realm of robotic surgical procedures, thus paving the way for more targeted training strategies and enhanced surgical performance (26).

CONCLUSION

The study demonstrates that skills from modern video gaming enhance laparoscopic performance, suggesting the integration of serious games into training could revolutionise clinical education. This marks a crucial step towards future gaming-based training modules or programmes for laparoscopic surgery, potentially serving as prerequisites for trainees and boosting motivation and engagement in training. In essence, gaming could complement traditional laparoscopic simulator training.

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ETHICAL APPROVAL

The study was approved by Jawatankuasa Etika Penyelidikan Manusia-Universiti Sains Malaysia (JEPeM-USM) with the study protocol code USM/JEPeM/21060389.

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