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ORIGINAL ARTICLE

The effect of a video game warm-up on laparoscopic proficiency in a simulated setting: a randomized trial

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Abstract

Background: The concept of warming up is well established in many complex motor skills, but has only recently been of interest to those performing surgery. An increasing body of evidence suggests that there may be a measurable benefit to warming up. However, the most efficient and cost-effective method of warm-up has yet to be established. This pilot study aims to determine if a simple video game may be used. **Methods:** Medical students and junior doctors with little laparoscopic experience were recruited and randomized to either the control group ($n = 10$) or the intervention group ($n = 10$). The control group performed three increasingly complex simulated laparoscopic tasks and the time and number of errors were recorded. The intervention group spent 10 min warming up on a Playstation 3 Move video games console before performing the same simulated tasks. **Results:** The performance of both groups was similar for the first two tasks. However, on the third and most complex task, the intervention group made significantly more errors than the control group. **Conclusions:** Although the Playstation 3 Move video game appears to replicate laparoscopic simulation well, it does not appear to offer any benefit in performing warm-up. The results of this study suggest that warming up may be more complex than previously understood.

Keywords: *simulation; minimally invasive surgery; video games*

Introduction

The concept of warm-up before undertaking a complex task is well established in many aspects of life. Vocal warm-up has been shown to improve the quality of the singer's or speaker's voice;[1,2] ballet dancers who perform a pre-procedure warm-up have improved aerobic energy utilization;[3] and a golf-specific warm-up significantly improves golfers' performance.[4] Conduction velocity in muscle is improved after a warm-up activity[5] and importantly, cognitive arousal in tennis players is improved by a pre-game swing warm-up.[6] It is therefore understandable that a complex psychomotor task such as surgery may benefit from warming up. However, it is an area that has not previously generated much research. The advent of laparoscopic surgery and the development of simulation to teach laparoscopic skills have opened the door on analysing the effect of warm-up on surgical performance. Several recent studies have demonstrated an improvement in performance on a simulator after warm-up exercises[7–9] and even an improvement in surgical performance of laparoscopic cholecystectomy in live patients after warm-up.[10]

If warm-up was to be adopted into surgical practice, it could be envisaged that several problems may prevent its uptake. A high-fidelity simulator such as the LapSim (Surgical Sciences Ltd, Gothenburg, Sweden) costs in the region of AUD$120,000, is not portable and requires routine maintenance and software updates. Even a low-fidelity system such as the Society of American Gastrointestinal and Endoscopic Surgeons Fundamentals of Laparoscopic Surgery Simulator costs AUD$2200 per unit, has limited portability and requires the regular purchase of consumables for at least AUD$25 per item. In modern practice, where trainees move frequently between institutions and surgeons rarely find themselves operating in the same operating room regularly, both of these systems may be impractical. A portable, low-cost system would be the ideal.

Video games are now ubiquitous in modern life; 180 million seventh-generation consoles have been sold. A review article by Lynch et al.[11] suggested that those who play video games may be better at laparoscopic surgery. Laparoscopic surgery has many similarities with playing video games: the instruments are remote from the subject and the user has to translate a mental three-dimensional image into movements on a two-dimensional screen. It can therefore be surmised that a video game warm-up would be ideal in preparation for performing laparoscopic surgery.

The aim of this paper was to determine if warm-up on a video games console improves performance on a laparoscopic simulator.

Materials and methods

Participants

This was a prospective randomized controlled trial. Approval was obtained from the Human Research and Ethics Committee at the Women's and Children's Hospital, Adelaide (WCHA) (REC2380/6/14). Participants were recruited from junior doctors and medical students undertaking their paediatric placement at WCHA. Informed consent was obtained from all participants. The participants were asked to fill out a questionnaire covering demographics and previous experience of simulation, video gaming and laparoscopic surgery; this last area was rated on a 5-point Likert scale from 1 (novice) to 5 (experienced). Participants were then randomized using an online randomization generator (www.sealedenvelope.com) to either the control group or the intervention group.

Study design

The intervention group were asked to perform a warm-up on the PlayStation 3 (Sony Corporation, Tokyo, Japan) console (PS3) using the PlayStation Move (Sony Corporation, Tokyo, Japan) control system. This system was chosen because of its portability (Fig. 1) and cost (approximately AUD$249). The warm-up task involved playing the game Flight Control HD (Namco, Tokyo, Japan), where players have to land virtual aeroplanes on colour-coordinated runways. Two Move controllers are used to drag the aeroplanes to the specific runway, and as time progresses, the speed of the planes and the number coming in to land increase. When two aeroplanes hit each other, the game is over. Participants had to hold one controller in each hand but could utilize either one or both depending on preference. Although this game does not involve any simulated surgery, it was felt that the game play was very similar to the control of laparoscopic instruments, in that it involved three-dimensional movement of the controllers, analogous to laparoscopic instruments, to create two-dimensional movement on the screen. Participants were given a maximum of 10 min to play and could attempt as many times as possible. The length of time they played and the highest score they achieved were recorded in an Excel (Microsoft, Seattle, WA) spreadsheet. The intervention group then proceeded immediately to the laparoscopic tasks.

Figure 1. The PlayStation 3 console and the PlayStation Move control system.

All participants performed the same series of progressively more difficult tasks on the LapSim. The LapSim has previously been validated as a training tool for laparoscopic surgery.[12–14] Each task was performed once. The first task was a simple camera navigation task. Six coloured spheres have to be targeted with the left hand instrument. The second was the instrument navigation task, where ten coloured spheres have to be touched by an instrument with the same colour tip. The third task was the clip applying task and is the most complex. This task involves applying two clips to a vessel and then dividing it. The LapSim records multiple variables regarding accuracy and performance. Each task was time limited to 3 min, and the instruction sheet made it clear that participants were to try to be accurate and not worry if they did not complete the task in the allotted time.

The primary outcome measure for the study was performance on the LapSim. It was also intended that if enough participants could be recruited, secondary outcomes would be measured. The planned secondary outcomes were the effect of level of laparoscopic experience on the efficacy of warm-up; the effect of length of warm-up on the efficacy of warm-up; the correlation between performance on the warm-up as measured by the number of aeroplanes landed and the performance on the simulator as measured by accuracy; and the effect of participant factors (such as video game experience) on the success of warm-up.

Analysis

Data were extracted from the LapSim and stored in an Excel spreadsheet. A score was then allocated to each participant for each task. For tasks 1 and 2, this was calculated as a function of time and the number of errors, and therefore a lower score signified better performance. As it was intended that task 3 would be the most difficult, and it was expected that participants who had not used the LapSim before may be unable to complete the task in a time limit, the data for this task was looked at independently: the number of errors, the blood loss caused and the damage to tissues were compared. Statistical analysis was performed with Prism v 5 (GraphPad Software, San Diego, CA). A P value <0.05 was considered significant.

An a priori power calculation was performed based on the data available for previous studies looking at warm-up. For a power of 0.8, it was calculated that 25 participants would need to be recruited to each arm.

Results

Twenty-eight participants were recruited, 20 medical students and 8 junior doctors. Fifteen were randomized to the control group and 13 to the intervention group. All participants completed the trial. Demographics were similar between the groups (Table 1).

Table 1. Demographics

	Control group (n = 15)	Intervention group (n = 13)	Significance
Age (years), mean (range)	26.3 (23–38)	24.2 (19 – 33)	ns
Gender ratio (M:F)	1.5:1	1.2:1	ns
Right handed (%)	100	92	ns
Laparoscopic skills			
Observed laparoscopic surgery (%)	100	100	ns
Assisted laparoscopic surgery (%)	93	92	ns
Performed laparoscopic surgery (%)	13	8	ns
Laparoscopic experience, n (range)	1.4 (1–4)	1.1 (1–3)	ns
Previous LapSim use (%)	33	23	ns
Video game experience			
Play now (%)	80	77	ns
Play ever (%)	87	100	ns
Played Flight Control® (%)	13	23	ns

ns, not significant.

In the intervention group, the mean time spent playing the warm-up task was 9.9 min (range, 8.9–10.0 min), and the mean number of aeroplanes landed was 31 (range, 17–46). Tasks 1 and 2 were performed successfully by all participants in both groups. Task 3 was only completed by four participants in the control group; the rest did not manage to apply the clips and divide the vessel in the 3-min time limit. In task 1, the control group had a mean score of 150.8 ($\pm$4.9) compared with 151.5 ($\pm$5.0) for the intervention group (P = 0.92) (Fig. 2). In task 2, the mean score was 159.2 ($\pm$1.9) for the control group and 152.9 ($\pm$3.9) for the intervention group (P = 0.15) (Fig. 3). For task 3, there was a significant difference in the blood loss caused (control group, 0.03 L; intervention group, 0.22 L) and a significant difference in the number of misplaced and dropped clips (control group, 1.4; intervention group, 3.0). The results for all three tasks are summarized in Table 2.

Analysis of the intervention group showed that a higher score in the warm-up task tended to show a better score in tasks 1 and 2 on the LapSim, but this was not statistically significant (Fig. 4).

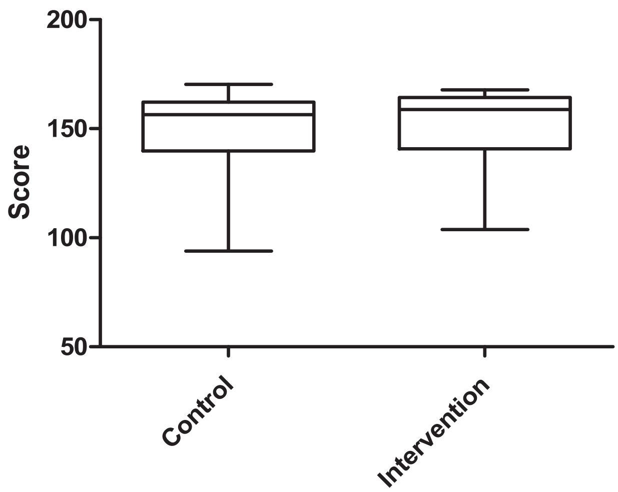

Figure 2. Task 1 scores, $P = 0.92$.

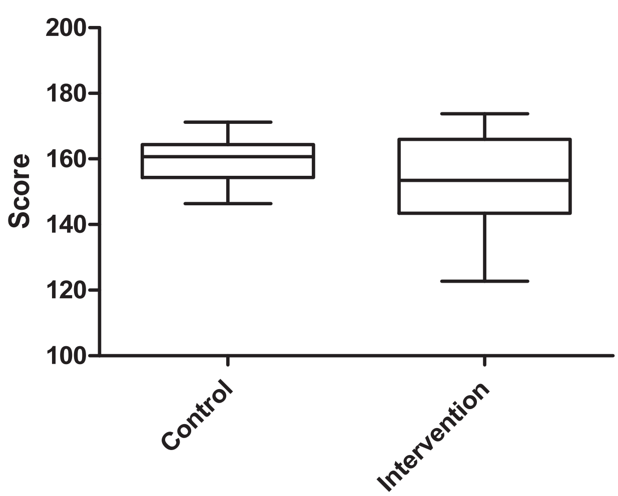

Figure 3. Task 2 scores, $P = 0.15$.

Table 2. Results for LapSim tasks

	Control ($n = 15$)	Intervention ($n = 13$)	Significance
Task 1			
Task time (s)	48.9	46.1	ns
Task 2			
Task time (s)	40.2	43.6	ns
Left hand time (s)	21.0	21.7	ns
Right hand time (s)	19.2	21.9	ns
Task 3			
Successful completion	4	0	ns
Blood loss (L)	0.03 (±0.02)	0.22 (±0.09)	0.049
Damage to other tissues (%)	44.3 (±7.3)	26.1 (±7.1)	ns
Total clip errors	1.4 (±0.3)	3.0 (±0.6)	0.02
Vessel amputated	2	5	ns

ns, not significant.

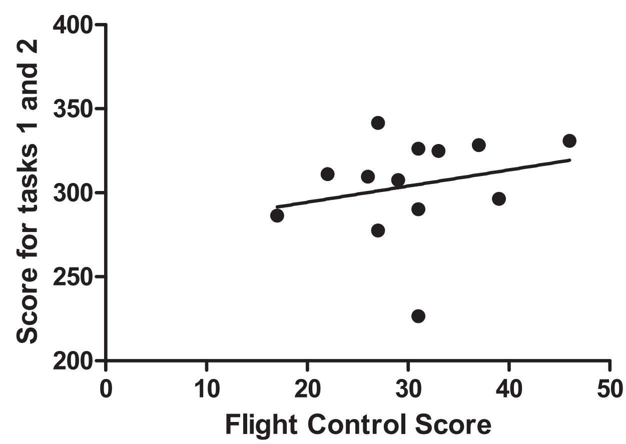

Figure 4. Intervention group scores comparing the warm-up score with the total score for tasks 1 and 2.

Unfortunately, the small number of participants prevented collection of meaningful data to analyse the other secondary outcomes.

Discussion

This study was performed to determine if there was a low-cost and portable system that might be feasible for warming up before performing laparoscopic surgery. There is good evidence that performance on a simulator correlates with real-life laparoscopic performance,[15] and therefore the effect of warming up on simulator performance was used as a proxy. The video games system was chosen not simply because of its low cost but also because of the recent addition of a motion-sensitive control, which may more accurately reflect the psychomotor skills involved in laparoscopic surgery. It was felt that this set-up could be easily used in a near-theatre location and in fact many surgeons may have previous experience of it.

Unfortunately, the results do not support the hypothesis that warm-up on this system can improve performance. For task 3, the intervention group performed significantly worse in several areas. There are several reasons why this may be the case, and they are related to the inherent weakness of the research. First, the study was under powered because recruitment was slow among medical students. Second, all participants read detailed instructions for performing the LapSim tasks and then watched demonstration videos for each task, and we postulate that this may in itself have acted as a form of warm-up. Third, less than a third of all participants had any experience of the LapSim and as the system is not particularly intuitive, those with no experience may have struggled to learn how the machine works in the short time that was available. The video game did not simulate surgery (that is the role of the LapSim equipment), but the movement and hand-eye coordination required were judged to be appropriate for the tasks utilized.

There is an increasing body of evidence to suggest that warm-up in surgical practice may be useful. Do et al.[7] showed that warm-up on a low-fidelity simulator improved subsequent performance on the same simulator, although this may simply be an example of the learning effect. Kahol et al.[8] showed that warm-up tasks performed on a high-fidelity simulator improved performance on a high-fidelity diathermy task; again this could represent a degree of learning effect. There is even evidence that warm-up in open surgery is beneficial.[16]

There is no doubt that practice on a laparoscopic simulator improves operating room performance,[15] and therefore it could be that the apparent warm-up effect noted in several papers is simply down to this learning effect. However, Calatayud et al.[10] demonstrated, in a well-crafted study, that warm-up on a virtual reality simulator task improved objective performance when undertaking laparoscopic cholecystectomy on live patients, evidence that certainly suggests that warm-up should be studied more, if not become an integrated part of surgical practice.[10]

In a similar study to the current work, Plerhoples et al.[9] used a smartphone device and touch-screen game to show a good warm-up effect before performing simulated laparoscopic tasks.[9] The current study used motion controllers to simulate the remoteness and two-dimensional visual computation of laparoscopy, whereas Plerhoples et al.'s set-up was significantly different from the movements and actions required in both low- and high-fidelity simulators as well as in live operating, and this raises the question of whether some other form of warm-up phenomenon was occurring. Other work has determined that mental rehearsal can improve laparoscopic performance,[17,18] and as video games have been shown to improve spatial abilities,[19] perhaps it is simply the mental aspect of the warm-up described by Plerhoples et al. that is beneficial. It is possible that simple mental warm-up without the physical aspect may suffice.

Neither the current study, nor that of Plerhoples et al. looked specifically at the length of time for warm-up, and this may play a significant role. It could simply be that the video game console set-up does not lend itself to warming up before performing laparoscopic surgery.

There is varying evidence as to whether video game experience has any effect on laparoscopic skills. Rosenberg et al.[20] and Rosser et al.[21] showed that video game aptitude correlates with laparoscopic skills. But Rosenberg et al.[20] also demonstrated that practice on video games did not improve laparoscopic skills. This may be one reason why video games did not seem to work as a warm-up in the current study. Although van Dongen et al.[22] showed that video game usage in children did not predict an improved laparoscopic skill set, Rosenthal et al.[23] showed that video games may contribute to the development of the laparoscopic skill set. There is still some work to be done to determine if video games really benefit prospective laparoscopic surgeons.

It is also apparent that further work, including large randomized controlled trials, need to be done to determine if warm-up is actually useful for laparoscopic performance or not. These studies should also look at what the best method of warm-up is, who benefits most from warm-up and the optimum duration of warm-up.

Conclusion

In conclusion, this study failed to demonstrate a warm-up effect from using a common video games console before performing simulated laparoscopic surgery. However, the study was underpowered, and perhaps further research may be useful in attempting to determine the most effective and easiest form of warm-up.

Conflict of interest

J. Andrews received a scholarship of AUD$30,000 dollars from Covidien during his time at the University of Adelaide. Covidien had no involvement in this study.

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