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Original Article

Does previous video game experience affect laparoscopic skills? Evaluation of non-medical school students with a novel laparoscopic training box

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Abstract: Background and objectives: Training is important to master skills in laparoscopic surgery. Various laparoscopic skills curricula have been developed to accelerate the learning curve of the trainees in a safer setting. Video games have become an integral part of daily life, and they have also begun to be used in medical education. We aimed to compare the laparoscopic skills of university students with or without history of video game playing with previously validated laparoscopic tasks on a newly developed laparoscopic training box. Materials and methods: A total of 60 university students were recruited from different faculties of Selcuk University other than medical school, and were divided equally into two groups according to their previous video game experience. The students were asked to perform seven different laparoscopic tasks. The performance durations for each task as well as the overall durations were evaluated according to the video game experience of the students. Results: Except for Task-6, all durations were statistically significantly shorter in the group with video game experience. The total duration was also shorter in this group. No difference was observed for the durations between male and female students in each group. Conclusions: Experience of playing video games seems to have a positive effect on laparoscopic skills. This can be due to improved hand-eye coordination and visual selective attention capacity, and decrease in response time to visual stimuli. This novel training box seems to be useful in general laparoscopic skills training.

Keywords: Laparoscopy, training, video game, training box, laparoscopic skill

Introduction

Laparoscopic surgery has been accepted widely, and is being performed commonly not only in urology but also in general surgery and gynecology all over the world. To perform laparoscopic surgery safely and effectively, several new and different surgical and psychomotor skills are required for the surgeon. These unique skills consist of adaptation to two-dimensional vision from three-dimensional one, bimanual dexterity, using long hand instruments while trying to reduce hand tremor, dealing with the fulcrum effect, and decreased tactile feedback [1]. Training with various simulation models is effective to master these skills and accelerate the learning curve of the trainees in a safer setting [2, 3]. Different simulation models and scenarios have been identified and validated; and they have been incorporated into various laparoscopic training curricula, thereby the burden on operation costs and time has been decreased effectively while increasing the safety of the patients [2-4]. These simulation models consist of *in vivo* anesthetized or *ex vivo* animal training models (porcine or rabbit), high- or low-fidelity virtual reality simulators (i.e. LapMentor®, LapSim®, Surgsim®, CAE Laparoscopy VR®, SimSurgery Education Platform®), inanimate training boxes (home-made or commercially available [i.e. FLS Trainer®, LapTrainer with SimuVision®, eoSim®, D-Box®, Pyxus®,

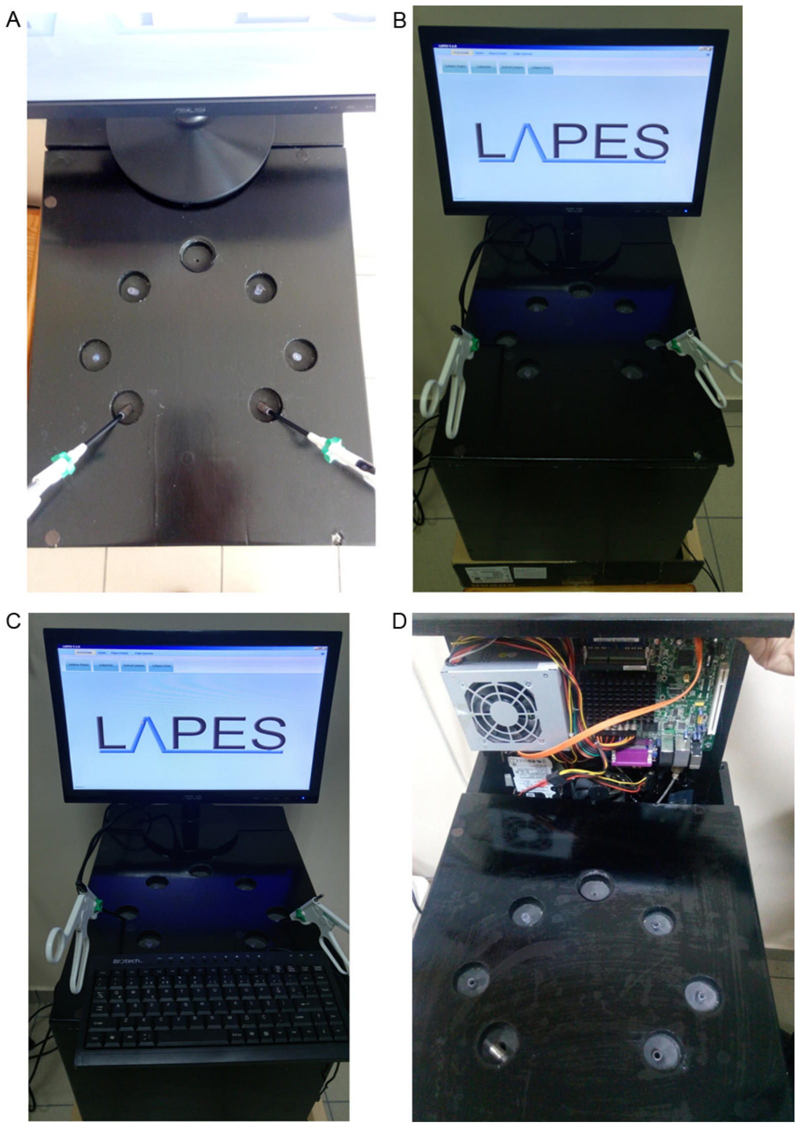

Figure 1. Various photographs of the novel laparoscopic training box showing different parts.

Laprotrain®, T3/T5/T9/T12 by 3-Dmed®]), and *ex vivo* animate box trainers (i.e. Pulsating Organ Perfusion Trainer®).

The training capacities of box trainers and virtual reality simulators (VRSs) have been studied, and no difference has been found in regards of LS acquisition [5]. There is a reliable correlation between both trainer types. Apart from VRSs, laparoscopic training boxes (LTBs) are generally inexpensive, easily realizable, lighter and more compact thus easy-to-move, and more available for most of the trainees. Furthermore, standard laparoscopic instruments can be used which enables reduction of the overall cost as well as preservation of the haptic feedback such in the real operative conditions. The LTBs can be used alone or in combination with VRSs in any LS curricula. As they are cheap and homemade training boxes can be built, they also have the advantage of providing training at home [6].

The VG industry, with the groundbreaking developments in its technology, has increased its popularity over the last years among a wide range of age, and continues to increase its market share. As the VGs have become an integral part of daily life, they have also begun to be used in medical education. Various researches have been published recently evaluating their role in LS training with different results.

In present study, we aimed to compare the LS of university students with or without history of VG playing with previously validated laparoscopic tasks on a newly developed LTB.

Material and methods

The present study was reviewed and approved by the Selcuk University Local Ethics Committee (approval number: 2012/169), and was therefore performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Participants were recruited from different faculties of Selcuk University other than medical school. Written informed consent was obtained from all participants.

A total of 60 university students were divided equally into two groups according to their previous video game experience (VGE). None of the participants has had any previous experience

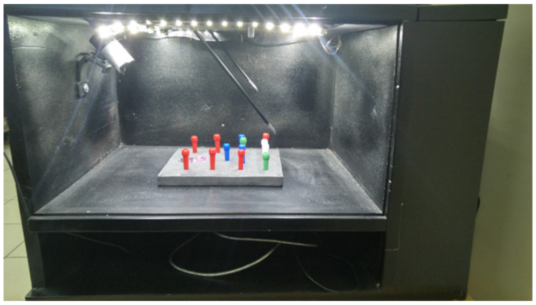

Figure 2. A lateral view of the novel laparoscopic training box showing the interior of it.

with a LTB or any medical knowledge such as laparoscopic surgery. Inclusion criteria were playing VGs at least for the last 4 years with a minimum duration of 6 hours per day and 3-5 times per week, and interest in "first person shooting (FPS)" games (such as Half Life, Counter Strike: Global Offensive, Call of Duty: Modern Warfare 2, Battlefield 2, BioShock, Medal of Honor: Allied Assault) as well as graphic-based programs such as Adobe® Illustrator CS6 and CorelDRAW®.

A LTB with dimensions of 55×36×35 cm (with a working space of 43×34×22), which has a shelf to keep the mini keyboard and the mouse as well as another place to put the built-in computer, was made of plywood with a reasonable price (**Figure 1**). Seven holes were drilled for trocar places, where commercially available plastic membranes were put in these holes with a central slit to place the used trocars that were cut in half. For the hardware, apart from the 15 inch liquid crystal display (LCD) monitor (ASUSTeK Computer Inc., Taipei, Taiwan), mini keyboard, mouse and a fixed webcam (1080p HD, Microsoft® LifeCam Studio™), the LTB included a computer with a Intel Atom processor, 2 GB RAM, 320 GB HDD and Intel Graphics 4000 graphics card. A U-shaped strip of white light-emitting diode (LED) lighting was mounted on the underside of the roof of the training box (**Figure 2**).

The software for scoring and analysis was developed with Rad Studio™ 2010 (Embarcadero®, San Francisco, CA, USA). The system defines two log-in types as trainer or trainee. The trainer records examples of the trainings while he/she can also give additional written explanation as well as minimum-maximum/optimum time to do and scores. The trainer can also assign certain trainee groups (such as urologist, gynecologist, general surgeon etc.) for specific exercises. Trainee logs in with unique username and password, and can see the exercises he/she can do. Trainee chooses the exercise, watches the example video, and then performs the exercise. The system records all exercises, and gives scoring (if defined earlier) according to the performance in regards of duration. The trainer can check these recordings concurrently or subsequently, and if desired, the system can send an e-mail to the trainer informing the exercise(s) performed.

All participants were asked to fill in a short form about their age, sex, school type, year of education, and previous VGE before performing the tasks. The LTB was put on a height-adjustable table that was placed in a free room reserved only for this experiment in our department. An explanatory video was prepared about the study, the LTB and the hand instruments that will be used; and was showed to all trainees. Then the participants were asked to perform a warm-up session of 3 minutes for grasping or carrying the matchsticks, peas and pieces of rope that were placed in the LTB with the hand instruments provided.

Before each task, all participants had to watch the example video at least once, as the software did not give permission to go directly to the tasks. They were advised to watch the explanatory video again in case they had something they did not understand well. Participants were allowed to practice again for 1 minute; this time specifically for the task they will do. After watching the explanatory video and practicing, the participants placed the needed hand instruments through the trocars and then clicked on the "Continue" button. The software began to record the tasks 3 seconds, the preset time given for preparation, after clicking the button. Participants were asked to click on the "Stop" button when they finished the task; and the system finished the recording of the task excluding the last 3 seconds (the pre-set time to reach the button). The participants were also told that they had freedom to begin the next task whenever they felt ready if they experienced any fatigue.

For each task, a square-shaped board of 15 x 15 cm dimensions has been prepared with a commercially available plastic, which was easy and cheap to setup. At the beginning of each

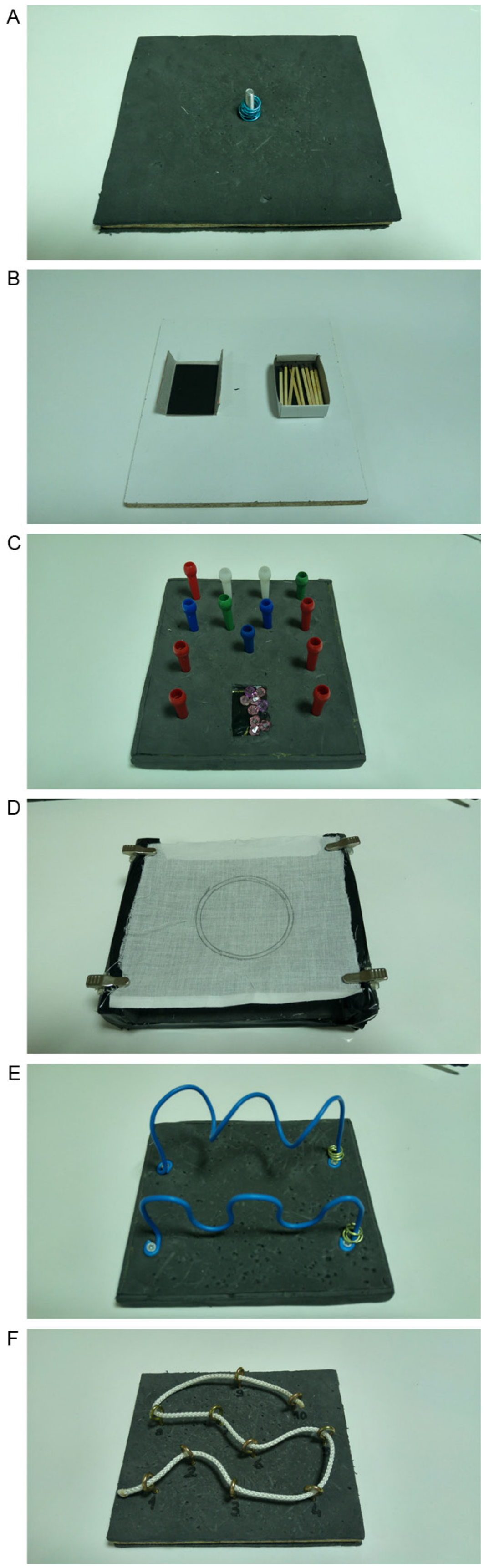

Figure 3. A. Task-1: Ring transfer, B. Task-2: Matchstick transfer, C. Task-3: Pea on a peg, D. Task-4: Cutting a circle, E. Task-5: One hand wire chaser and Task-6: Two hands wire chaser, F. Task-7: Rope guidance.

task, these prepared boards were placed through the right lateral window of the training box by an observer, who existed ready to help the trainees if they had any problem about the hand devices or tasks (**Figure 2**).

The trainees were asked to complete 7 tasks consecutively. These tasks were selected from previously tested and validated curriculums. Three of them (2 of them with minor modifications) were taken from the Program for Laparoscopic Urologic Skills (PULS) [7], of which 2 came from the Fundamentals of Laparoscopic Surgery (FLS) tasks [8]. The other 3 tasks were taken from the validated training course developed by Schreuder et al. [1]. The first task was a simplified modification of "peg transfer" task from PULS. The setup, descriptions, requirements and error criteria for these tasks are listed as follow (**Figure 3**):

Task-1: Ring transfer

This task is a modification of Task-2, "peg transfer" task. Although it is not a validated and a commonly used task, we decided to put this task in the first place as it is an easy version of Task-2, which can also be counted as a warm-up exercise at the beginning. The 10 rings randomly placed onto the board are grasped with either dominant or nondominant hand, and placed through a stick that is located in the middle of the board, and can be made of a nail at home. Ten seconds per dropped ring are added to the total time as a penalty. This task requires two graspers.

Task-2: Matchstick transfer

This task is also a modified version of "peg transfer" task that can be setup at home. A dozen of matchsticks are put in a matchbox, and the trainee grasps these sticks one by one with his/her right hand, transfers to left hand in the air and then puts in the left matchbox. The original "peg transfer" task was designed to develop depth perception and visual-spatial perception in a monocular viewing system by coordinated use of both dominant and non-

Table 1. Durations of all tasks for the groups with and without experience

	Duration (seconds)		*P* value
	Without experience	With experience	
Task-1	251.4 ± 66.8	159.6 ± 31.2	<0.001
Task-2	207.5 ± 50.2	107.4 ± 26.5	<0.001
Task-3	530.8 ± 198.2	332.7 ± 79.7	<0.001
Task-4	295.3 ± 89.7	250.3 ± 52.8	0.022
Task-5	216.9 ± 39.6	67.0 ± 12.2	<0.001
Task-6	303.8 ± 144.9	265.7 ± 74.9	0.207
Task-7	372.3 ± 167.1	261.2 ± 41.7	<0.001
Total	2493.6 ± 631.0	1758.5 ± 182.2	<0.001

Data are shown as mean ± standard deviation.

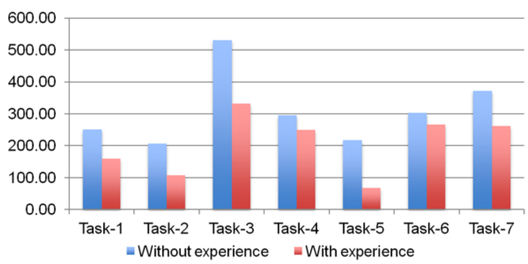

Figure 4. Column graphics showing the durations of the tasks for both groups.

dominant hands [8]. Ten seconds per dropped matchstick are added to the total time as a penalty. This task requires two graspers.

Task-3: Pea on a peg

15 pegs with different heights are placed on the board, and a little box containing 20 plastic pea-like materials are placed in front part of the board. The left side of the pegboard has to be completed with the left hand, and the right side with the right hand. When a pea is dropped on the board it has to be picked up again to be successfully placed on a peg. When a pea is dropped out of the board, it cannot be used again. The aim of this study is also to develop depth perception and visual-spatial perception, like the previous two tasks. Ten and twenty second are added to the total time as a penalty when a pea is dropped on the board or out of the board respectively. This task requires two graspers.

Task-4: Cutting a circle

A square-shaped gauze with an approximately 15 cm dimension is suspended above the board with clips. The trainee cuts a precise circular pattern from the gauze along two premarked rings with a 1 mm-space. This task aims to use of the nondominant hand to provide appropriate traction to the material and to position the gauze so that the dominant hand holding the scissors can cut it accurately. This exercise teaches the concept of traction [8]. A dissector and a pair of scissors are required.

Task-5: One hand wire chaser

Three rings are transferred one-by-one to the other side of the wire by using dominant hand. If the ring is lost by the grasper, ten seconds are added to the total time as a penalty. A grasper is required for this task. Task-5 and -6 are taken from the training course that was constructed by Schreuder et al. [1].

Task-6: Two hands wire chaser

This time, the board is positioned with the wire "configured in spiral style" in front. Three rings are transferred one-by-one to the other side of the wire, starting with the dominant hand. Both hands are used, and changing the hands after each curve in the ring is needed. If the ring is lost by the grasper, ten seconds are added to the total time as a penalty. Two graspers are required for this task.

Task-7: Rope guidance

The trainee is required to guide a long nylon rope through 10 metal rings following a predefined route with numbers. This task was modified from the original one by changing the needle with a nylon rope [7]. This task required two graspers.

Data were analyzed with SPSS for Windows v.15.0 (SPSS Inc., Chicago, USA) and NCSS 2007 (NCSS Inc., Kaysville, Utah, USA). Normality was tested with the Shapiro-Wilk analysis, and homogeneity of variance was tested using Levene's test. The descriptive analyses were given as mean ± standard deviation (SD) for the continuous quantitative variables and non-numeric variables were given as frequencies or percentages. Independent samples t test was used to compare the means of the groups. The level of statistical significance was set at $P < 0.05$.

Results

The mean ages were 22.9 (±1.4) and 23 (±1.6) years, and the percentages of male students

Table 2. Durations of all tasks for male and female students with and without experience

	Duration (seconds)					
	Without experience			With experience		
	Male	Female	*P* value	Male	Female	*P* value
Task-1	251.6 ± 72.9	251.1 ± 61.9	0.987	154.5 ± 24.6	164.8 ± 36.7	0.373
Task-2	206.3 ± 57.1	208.9 ± 43.2	0.887	107.8 ± 27.4	107.0 ± 26.6	0.936
Task-3	508.8 ± 176.2	556.0 ± 224.7	0.525	323.0 ± 91.1	342.5 ± 68.2	0.513
Task-4	284.5 ± 109.6	307.6 ± 61.6	0.491	255.0 ± 53.3	245.7 ± 53.7	0.636
Task-5	519.5 ± 210.6	547.4 ± 230.9	0.732	360.7 ± 54.3	402.4 ± 73.6	0.088
Task-6	332.3 ± 167.7	271.3 ± 110.8	0.257	270.3 ± 73.5	261.0 ± 78.6	0.739
Task-7	391.9 ± 195.8	349.8 ± 130.4	0.500	265.6 ± 46.6	256.8 ± 37.2	0.572
Total	2494.8 ± 736.3	2492.1 ± 512.5	0.991	1736.9 ± 205.2	1780.1 ± 160.3	0.526

Data are shown as mean ± standard deviation.

were 50% and 53.3% for the groups with and without experience, respectively, without any statistical difference ($P > 0.05$). The mean durations of all tasks for both groups are given in **Table 1**. Except for Task-6, all durations were statistically significantly shorter in the group with VGE (**Figure 4**). The total duration was also shorter in this group. Although the mean duration for Task-6 was shorter in the group with VGE, this difference did not reach a statistical significance. When each group was evaluated separately, no difference was observed for the durations between male and female students (**Table 2**).

Discussion

The advent of new surgical methods and devices, such as endoscopic, laparoscopic and robotic surgery, caused the need for systematic skills training in an efficient and safe environment. Concerns for patient safety, malpractice issues, and restrictions for working hours of residents by recent laws have also contributed to this need. Researchers have shown that LS training not only improves the trainee's operative time, but also reduces the complication rates [9, 10]. Moreover, a recent randomized study demonstrated that a preoperative warm-up session improves the psychomotor performance and reduces the possible errors during laparoscopic surgery even in experienced laparoscopic surgeons [11]. Therefore, it is important and essential to have not only a structured LS curriculum, but also a handy and readily available LTB. However, even you have a good curriculum, a useful LTB and sufficient dedicated time for LS training, something that may increase the benefit of this training can be still missing: feedback, especially from a mentor. Most researches have shown that external verbal feedback (either positive or negative) is an important and influential force in the training of medical students and surgical residents, and is most effective when given specifically, timely, in adequate quantity and in a nonjudgmental fashion by an expert [12-15].

There are several commercial LTBs and VRSs that analyze the volume, distribution, economy, angle and smoothness of instrument movements, and give numerical and/or statistical results to the trainee after completion of the task(s). However, these devices are generally expensive, and not every center can afford to incorporate them into their education curriculum. Besides these expensive training boxes/simulators, some authors have developed themselves either low-cost laparoscopic simulators with reasonable budgets or complex designs used for single-port surgery training [16-18]. Moreover, Rudderow et al. succeeded to develop a compact and cost-effective laparoscopic simulator with a web-based laparoscopic technical skills assessment device, which provided real-time numerical gesture analysis feedback to users in the form of percentile scores [19]. After its feasibility, validity and reliability were confirmed, they concluded that this device objectively and immediately identified areas of strengths and weaknesses in movement analysis amongst surgical peers.

It is a well-known fact that getting a bad result (which can be defined as a negative feedback) at the beginning of a training period may be stressful, especially for novice [20]. Porte et al. observed that the trainee group that got only verbal feedback from an expert showed retention of gained skills on delayed performance testing when compared to the groups that received only computer-generated feedback or both [14]. Apart from this, it was also shown that a summary feedback after a task completion was more efficacious than a concurrent feedback that was given while a task was being performed [21].

With keeping these issues in mind, we developed this LTB that records the tasks performed by the trainees. With the aid of the mini-computer placed in it, a trainee can get numeric results like the total duration of the performed task. Moreover, if asked, the computer has a capacity of giving points for the duration of the tasks the trainee performed according to predefined duration intervals for each task. However, what is more important is that an expert can watch the trainee during the performance or at a later time with this training box. The latter option is more important, especially when the expert is far away from the training center. Besides this, the common handicap of not having an expert when a trainee performs tasks on his/her own after completing a LS course can be overcome with this property. Additionally, the expert can send a verbal or a written feedback to the trainee's account concurrently or subsequently.

Researchers have observed faster reacting times, better performance for hand-eye coordination tasks, improved spatial visualization, enhanced visual selective attention capacity and decrease in response time to visual stimuli in people who grew up playing VGs [22-25]. With these observations and their potential to transfer psychomotor ability and skill sets, VGs have begun to be used in medical education. Interestingly, practicing for LS and/or preoperative warm-up can also be performed with VGs besides LTBs and VRSs [26, 27]. The accessibility of gaming systems is an important factor making these devices, especially the handheld ones, a good tool for practicing. Various papers in different trainee groups with different results have been published about the effect of playing VGs on LS [27-30].

Van Dongen et al. compared the total scores for performing 4 tasks on LapSim® between surgery interns and first-year secondary school students, both groups with and without previous VGE [28]. Interns with VGE scored significantly higher than interns without VGE. However, no difference was observed between schoolchildren with and without VGE. Interns with VGE scored significantly higher than schoolchildren either with or without VGE; but no significant difference was measured between interns without experience and both of schoolchildren groups. Although their results did not predict any advantage of playing VGs in children with regard to adults, they concluded that next generation of surgeons might benefit from VGE, as gaming children were successful as nongaming adults.

Ju et al. evaluated the effect of playing VGs by performing two laparoscopic tasks, bead transfer and suturing, in 23 less experienced and 19 more experienced physicians, residents and medical students [29]. Regardless of the laparoscopy experience, they found a significant improvement in bead transfer scores both in Nintendo Wii® (Wii) and PlayStation2® (PS2) groups; while no difference was observed in suturing scores in both groups. They concluded that Wii and PS2 could be low-cost alternatives to expensive simulators at least for some of the laparoscopic tasks.

In another study, from the residents who practiced with either XBOX 360®, Nintendo DS® or traditional laparoscopic simulator for 6 weeks, the greatest improvement was observed in XBOX group [30]. Interestingly, the residents practiced with LTB noted the lowest improvement in the time to perform peg transfer task. Jalink et al. showed that a preoperative warm-up with a custom-made Nintendo VG significantly improved the scores in peg transfer task [27].

Our results were in concordance with that of van Dongen et al. [28]. As they concluded that interns with VGE scored better, we also observed that the students with VGE had shorter durations for all tasks, except Task-6. The duration for Task-6 was lower in the group with VGE, but it did not reach a statistical significance. Although we could not find a valid explanation for this result, we think that using two hands may have facilitated the task, thus caused no significance. On the other hand, this result may also be due to relatively small numbers in each group. Even though we did not evaluate whether regular training with VGs affected the progress in LS, we think that our results have a supportive value to that of Jalink et al. [27] and Adams et al. [30].

Our study has certainly some limitations that should be listed here. Firstly, the number of participants in each group was relatively small, and we determined the numbers without a power analysis. Secondly, although the variations were minor, the modified tasks might have affected the results, as they were not the original validated exercises. Thirdly, although this LTB was a new designed one, it only had new features for recording the tasks performed by the trainees and sending them to the mentors, while the remaining parts and functions were similar to the previous ones. For this reason, no face and construct validity was performed. Before the study, 3 urologists, 2 gynecologists and 2 general surgeons with various degrees of laparoscopic expertise tested the newly developed LTB, and concluded that it did not have any difference for usage when compared with a commercially available LTB (data not shown). And lastly, apart from what Schreuder et al. [1] did, no total scoring points according to the recorded time and pre-defined penalty points for mistakes have been calculated. With an inspiration from Schreuder et al. [1], we only added pragmatically an extra time as a penalty to the total time. We also did not perform a scaling for the quality of the performed tasks like Brinkman et al. did [31]. We know that pre-defined penalty and scoring points would give more accurate results, but it is quite complicated to arrange this scoring, as some of the tasks are modified versions of previously validated tasks.

On the other hand, this study has some shinning points. Seven different tasks with different degrees of difficulty were used. Trainees without any prior medical knowledge have been included in the study. The groups seem quite homogenous and similar to each other, as the age range and female-to-male ratio are alike for both groups.

We fully appreciate that this can be rather called a pilot study for the novel LTB. It should have been better if we have evaluated the trainees without VGE after a period of playing VGs. By this way, it would have been possible to conclude better whether VGs may have an effect on LS. We are currently in the process of planning a new study with this concept. Additionally, a multi-institutional study is being planned to assess the effect of concurrent versus subsequent feedback on the performances of trainees, which would appropriately test the usefulness of the new LTB.

Experience of playing VGs seems to have a positive effect on LS. This can be due to improved hand-eye coordination and visual selective attention capacity, and decrease in response time to visual stimuli as proposed earlier. However, it seems that some more studies are required to conclude that video gaming can be a routine part of LS training. This novel training box seems to be useful in general LS training, but further studies are needed in order to evaluate the efficiency of its recording property and either concurrent or summary feedback is more efficacious in LS training.

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Disclosure of conflict of interest

None.

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