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REVIEW ARTICLE

The role of video games in facilitating the psychomotor skills training in laparoscopic surgery

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Abstract Several studies have evaluated the impact of video games (VGs) on psychomotor skills in laparoscopic surgery. Our review of literature revealed that prior VGs experience ameliorates the initial skill level of novice trainees and accelerates their learning curve by facilitating a better perception of 3D images, ambidexterity, and tone reflexes. The published studies are unfortunately limited by the small number of participants, the heterogeneity of the sample, the endpoints, and the evaluation tools of the studies. Randomized control studies with strict inclusion criteria and valid evaluation tool are required before including this concept in surgical educational programs.

Keywords Video games · Laparoscopic surgery · Psychomotor skills

Introduction

In 1992, Satava embraced the new era of technologies by announcing the age of the "Nintendo surgeon" [1]. This highlights the new arising skills required for surgeons to overcome the technical difficulties of laparoscopy such as the perception of 2D images, the hand-eye coordination, the low tactile feedback, and the lack of bimanual dexterity [2, 3]. Subsequently, virtual reality simulators (VRS) and box training simulators (BTS) were developed with interactive scenarios similar to real-life situations to allow playful learning and acquisition of laparoscopic skills [4, 5]. These skills are largely similar to those acquired by players of video games (VGs): long attention span, rapid mental processing, high level of concentration on tasks, hand-eye coordination and visual-motor skills, resistance to distraction, and sensitivity to information in the peripheral vision [6–8]. VGs are invading the majority of the available electronic devices, and the gamers are offered multiple types of consoles (keyboard, mouse, joysticks, and touch screens) and games. Yet little is known concerning the role of VGs in surgical education [9, 10]. We, therefore, reviewed the literature to assess the role of VGs in the acquisition and sharpening of laparoscopic skills.

Methods

We searched in MEDLINE and EMBASE for the relevant articles with the keywords: surgery, laparoscopy, skills, video gaming, training, dexterity, hand-eye coordination, psychomotor, virtual reality, box training, surgeons, and residents. We limited the results to the articles written in the English language published before July 2015. All the results were sequentially screened by two authors for title and abstract. Forty-six articles were found with 26 articles directly related to our search subject: 13 observational studies, 12 control studies, and 1 validation study.

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Proof of concept

The potential role of VGs in the acquisition and sharpening of the laparoscopic skills has long been debatable. The available data indicates that VGs performance is predictive of laparoscopic skills and did not correlate to the traditional surgical skills required for open surgery [11]. VGs players acquire laparoscopic skills faster and retain the learned skills for a longer time (p = 0.03 and 0.04, respectively) [12]. The role of VGs may be even observed on the short term. Short warm-ups of 6–10 min with a game before using a laparoscopic evaluation accelerate the performance of a maneuver and decrease the occurrence of errors [3, 13]. The role of prior VGs experience and VGs training on skills development was studied on several occasions (Tables 1 and 2).

The console of VGs

Several authors have correlated the skills proficiency to the type of console used. In 2002, 25 surgery residents with limited experience in surgery were evaluated according to their computer-VGs experience. VGs players (n = 10) made fewer errors and achieved their tasks in a shorter time on the Mentice Medical Simulation (MIST-VRS, Gothenburg, Sweden) (p = 0.035) [14]. The Wii (Nintendo Co, Ltd., Kyoto, Japan) is another type of console characterized by a handheld pointing device able to detect 3D movements that allows the gamer to play using physical gestures. The effect of the Wii is yet to be determined in well-designed controlled study as the available data are conflicting. A higher Wii score was correlated to a better performance on the BTS ($p < 0.001$) [16]. In line with these results, obstetrics/gynecology residents and interns (n = 30) were shown to improve their laparoscopic skills on the pelvic BTS after playing Supermonkey ball for 10 min between two simulations [17]. Conflictingly, Boyle et al. failed to demonstrate a statistically significant difference between Wii gamers (11 medical students) and non-Wii gamers (11 medical students) [18]. The potential role of the X-Box console was evaluated in one study only. Eleven students without surgical or previous VGs experience were divided into two groups among which five students trained for 6.2 h on VGs during the 2 weeks between the sessions. In this study, the X-Box VGs failed to enhance laparoscopic performance skills as the two groups did not show any statistical significance [19].

The type of VGs

The type of VGs was evaluated in multiple studies for differences in the potential gain of skills proficiency. In 2009, Schlickum et al. subdivided 40 students into three groups that included 10 controls, 15 VGs players of a 3D first-person shooter game (FPSG) (Half Life by Valve Software Corp, Bellevue, WA), and 15 VGs players of a 2D non-FPSG (Chessmaster by Ubisoft Entertainment SA, Rennes, France). In comparison to non-players, all gamers showed a statistically significant improvement in their performance between the first test at enrollment and the second test after 5 weeks of intensive training. It is noteworthy that the 3D FPSG had a greater transfer effect in comparison to 2D non-FPSG [20]. Another study by the same authors subdivided 26 subjects into three groups that included four controls, 11 VGs players of a 3D FPSG, and 11 VGs players of a 2D non-FPSG. After a 5-week intensive training, the scores on the MIST-VRS of the FPSG group were significantly better than their counterparts. The authors attributed these findings to the significant improvement in the visuospatial awareness and 3D perception acquainted with FPSG [21]. The participants in these two studies were not in the medical field thus the extrapolation of these results to medical education is limited.

The studies enrolling surgical residents (n = 21) used a balancing game (Marble Mania by Kororinpa in Europe and Japan; Hudson Soft Co, Ltd., Tokyo, Japan) on the Wii. Players (n = 14) had an improvement in the proficiency of the non-dominant hand and better ambidexterity ($p < 0.05$) [22]. The score on the balancing game correlated to the VRS performance (METI Surgical SIM by METI Corp now owned by CAE Healthcare, Sarasota, FL) but not to the BTS (Tulane Trainer). Performance on fine-motor VGs with extensive use of motion-sensing technology correlated strongly with various instances of VRS performance but not with the BTS performance [23].

The prior experience of VGs

Theoretically, VGs help the adaptation of the brain to laparoscopic maneuvers thus prior VGs experience would accelerate the achievement of predetermined proficiency skills (p = 0.01) [24]. Interestingly, prior VGs experience only favors adult players to their counterparts while no difference was found among children on both VRS and BTS [25, 26]. However, Fanning et al. demonstrated that teenagers with prior VGs experience (n = 15) completed the Bean and Pom-POm Drop, the Checkerboard Drill, and the Bead Manipulation 21–41 % faster than obstetrics/gynecology residents (n = 15) [27].

Paschold et al. evaluated 279 medical students via Sim Surgery VRS according to their past VGs experience (often/frequently vs. rarely/not at all). The study demonstrated that VGs experience is correlated to a higher score with an odds ratio of 2.4 (95 % CI 1.3–4.2; p = 0.003) [28]. When analyzing the VGs experience on VRS in a study of high school students (11.25 h/week), college students (21 h/week), and residents

Table 1 Studies that assess past VG experience on laparoscopic skills

Studies	Type of study	Subjects	Laparoscopic experience	Game experience	Simulator used	Results	Limitations
Grantcharov et al. Denmark [14]	Observational	25 SRes (40 % VGP)	Limited	N/A	MIST-VR	VGP fewer errors ($p = 0.035$).	-VG experience not quantified - Limited VR to OR transfer validity
Madan et al. USA [15]	Comparative	68 MS	None	Variable	Porcine model (AM)	VG experience does not predict baseline LapSk	N/A
Rosser et al. USA [30]	Cross sectional analysis	- 21 residents - 12 attendings (57 % VGP)	3.1 years for residents 12.9 years for attendings	>3 h/week	Top gun LapSk and suturing (box)	VGP 33 % better performance ($p < 0.05$)	N/A
Shane et al. USA [24]	Observational	- 11 MS - 15 SRes (42 % VGP)	Novices	>3 h/week	MIST-VR	VGP quicker proficiency (1 vs 9 trials; $p = 0.013$)	VR gives advantage to VGP
Van Hove et al. USA [12]	Observational	35 SRes (37 % VGP)	N/A	N/A	MIST-TELS (box)	VGP scored higher (25.9 vs 20.1; $p = 0.03$)	-Dropout rate of trainees 24 % -Previous laparoscopic experience is not noted
Nomura et al. Japan [32]	Observational	43 MS	None	N/A	Pro-MIS (VR)	VGP are faster	-VR is used as an indicator of OR LapSK.
Fanning et al. USA [27]	Comparative	- 15 teen VGP - 15 SRes non-VGP	Limited	Expert	Validated homemade simulator (box)	VGP are faster	N/A
Badurdeen et al. UK [16]	Observation	20 MS and doctors	Limited	Limited	Validated homemade simulator (box)	Good Wii VGP scores better on the box ($p = 0.008$)	Small sample size
Kennedy et al. Ireland [31]	Correlation	38 MS	None	16 experts (>7 h/week)	Pro-MIS (VR)	VGP better psycho-motor skills	Presence of confounding factors (sports, music)
Paschold et al. Germany [28]	Observational	279 MS	None	Variable	Sim Surgery Simulator (VR)	Frequency of video gaming is associated with quality of first-time VR performance	Limited VR to OR transfer validity
Van Dongen et al. Netherlands [25]	Observational	- 20 interns - 26 children (50 % VGP players)	None	10 h/week	Lap Sim Simulator (VR)	VGP scores better than non-VGP	Limited VR to OR transfer validity
Rosenthal et al. Switzerland [26]	Comparative	- 32 children - 20 residents - 14 surgeons	Variable	Variable	Mentice SA simulator (box)	Lowest performance is found in children with low VG experience.	N/A
Borahay et al. USA [29]	Cross sectional pilot study	- 17 students - 11 residents	Variable	Variable	3D Med trainer platform (VR)	Students performed comparably to the residents in simple exercises ($p > 0.05$), but not in complex exercises ($p = 0.001$).	Small sample size

AM animal model, *VG* video game, *LapSk* laparoscopic surgical skills, *MS* medical students, *N/A* not available, *OR* operation room, *SRes* surgical resident, *VR* virtual reality

Table 2 Randomized control studies that assess the effect of VG on influence laparoscopic performance

Studies	Type of study	Subjects	Laparoscopic experience	Game experience	VG training	Simulator used	Results	Limitations
Rosenberg et al. USA [19]	RCT	-5 gamers -6 controls	None	None	2 weeks of VG (6.2 h)	Swine model (AM)	No difference between the two groups.	N/A
Sadandanan et al. USA [17]	RCT	30 residents and interns	Variable	Variable	10 min Wii gaming between two sessions on the simulator	Pelvic trainer (box)	VG improved laparoscopic skills and time to complete the task.	N/A
Schlickum et al. Sweden [20]	RCT	-11 played 3D FPS -11 played a 2D non-FPS -4 controls	Novices	N/A	5 weeks	MIST-VR and GI mentor (both VR)	FPS group scored significantly better.	Limited VR to OR transfer validity
Schlickum et al. Sweden [20]	RCT	-15 played HL -15 played CM -10 controls	Novices	N/A	5 weeks	MIST-VR and GI mentor (both VR)	HL and CM VGP improve laparoscopic skills ($p = 0.035$ and 0.008)	Limited VR to OR transfer validity
Bokhari et al. USA [22]	RCT	21 SRes	Novices	N/A	14 played 15 levels of Marble Mania on the Wii using the Wii Mote controller.	Pro-MIS (box)	Wii VGP was faster, more proficient, and made fewer errors.	N/A
Plerhopels et al. USA [13]	Comparative	-20 intervention group -20 controls	Novices	Variable	10 min mobile device balance gaming	Pro-MIS (box)	The intervention group made fewer errors.	N/A
Boyle et al. Ireland [18]	RCT	-11 MS played the Wii -11 MS controls	None	None	3 h/week	Pro-MIS (VR and box)	Wii playing ameliorates performance of laparoscopic skills.	N/A
Rosser et al. USA [3]	Comparative	303 surgeons	Expert	Variable	6 min of three validated VG before the drill	Top gun laparoscopic skills and suturing program (box)	VG training prior to the drill improved time to accomplish the task.	N/A
Giannotti et al. Italy [33]	RCT	-21 SRes played the Wii −21 SRes controls	Novices	Variable	Wii for 1 h/day, 5 days a week for 4 weeks	Lap mentor (VR)	The Wii group performed better.	-Short duration of Wii training -Heterogeneity of surgical experience
Middleton et al. USA [34]	RCT	-Two intervention groups (A: 9 MS, B: 7 MS) -Control (7 MS)	None	Variable	-A: 2 h/day for 2 weeks -B: 4 h/day for 2 weeks	Lap mentor (VR)	The Wii group performed better.	-Small sample size -Short duration of Wii training - Limited VR to OR transfer validity
Millard et al. USA [11]	RCT	29 veterinary students	Limited	Variable	N/A	N/A	Association of VG performance to laparoscopic skills.	N/A
Willis et al. USA [23]	RCT	20 MS	Novices	Variable	Completed the Marble Mania game on the Wii	Tulane Trainer (Box) and METI Surgical SIM (VR)	Correlation between VG and VR performance.	N/A

AM animal model, *CM* Chessmaster, *FPS* first-person shooter, *HL* Half Life, *MS* medical students, *N/A* not available, *RCT* randomized control trials, *SRes* surgical resident, *VG* video game, *VR* virtual reality

(3 h/week), students performed comparably to the residents in simple exercises ($p > 0.05$) but required longer time to complete complex exercises ($p = 0.001$) [29]. When analyzing the VGs experience on BTS in a study evaluating suturing skill, prior VGs experience with more than 3 h per week was more important than the surgical experience [30]. The level of experience was evaluated objectively via a scale (The Amount of Video Game Experience Scale) designed specifically for the study but was not published. Overall, medical students with VGs experience showed better psychomotor skills and quicker acquisition of laparoscopic skills when assessed on the Pro-MISS VRS (Haptica, Dublin, Ireland). The factors that predicted better laparoscopic skills were favorableness of television games, manual dexterity, and confidence about driving [31, 32].

Two prospective studies evaluated the prior VGs experience. The first showed a significant improvement in performance following a Wii training of 1 h/day for 5 days/week for 4 weeks [33]. The second compared seven controls to two groups of medical students with 2 ($n = 9$) and 4 ($n = 7$) hours of Wii training within the previous month. All the students with Wii training outperformed the control group and improved their basic surgical skills most notably with the non-dominant hand [34].

Tailored VGs

Recently, Jalink et al. developed a game that used the Wii system and Wii Mote controller to create a VRS. The Wii controller was modified into a driller and a grasper. The game required the player to drill and to move the pieces using the grasper. This simulator allowed inverted movements, eye-hand coordination, depth perception, and ambidexterity thus was highly rated for both the software and the hardware. Further results are awaited once the final version of the game is available [35].

Limitations and conclusion

When interpreting the published literature, it is essential to keep in mind the small number of participants, the heterogeneity of the sample, the endpoints, and evaluation tools of the studies. It is noteworthy that the Copenhagen 2015 ICOSET meeting clearly stated that the transfer validity of any simulator has not yet been proven which limits the results of the available data [36]. Effectively, the published literature is sparse and limits the impact of the simulation training programs to the potential benefit on the clinical learning curve [37, 38].

The available literature suggests that the next generation of surgeons would potentially benefit from their prior VGs experience during childhood. Prior VGs experience ameliorates the initial skill level of novice trainees and accelerates their learning curve by facilitating a better perception of 3D images, ambidexterity, and tone reflexes. Subsequently, tailored VGs may be added to the early phases of the surgical training programs although the impact of VGs experience of surgical skills in not yet fully evaluated. Randomized control studies with strict inclusion criteria and valid evaluation tools are required to determine the adequate level and type of VGs experience required for the professional development of laparoscopic skills.

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