Validation of a video game made for training laparoscopic skills

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Publication date:
2014

Chapter 2

The effects of video games on laparoscopic simulator skills

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American Journal of Surgery. 2014 Jul;**208(1)**:151-156.

Abstract

Background: Recently, there has been a growth in studies supporting the hypothesis that video games have positive effects on basic laparoscopic skills. This review discusses all studies directly related to these effects.

Data sources: A search in the PubMed and Embase databases was performed using synonymous terms for video games and laparoscopy. All available articles concerning video games and their effects on skills on any laparoscopic simulator (box trainer, virtual reality, and animal models) were selected.

Conclusions: Video game experience has been related to higher baseline laparoscopic skills in different studies. There is currently, however, no standardized method to assess video game experience, making it difficult to compare these studies. Several controlled experiments have, nevertheless, shown that video games cannot only be used to improve laparoscopic basic skills in surgical novices, but also as a temporary warming-up prior to laparoscopic surgery.

Introduction

In 1992, Richard Satava wrote a letter to the editor of JAMA, in which he announced the age of the "Nintendo surgeon", embracing all new kinds of technologies used by the next generation of surgeons, ranging from video games to the then-new laparoscopic surgery [1]. Back then, little was known about the similarities between these two technologies. But times have changed, and the relationship between video games and good surgical practice seems to be a returning topic.

It is paradoxical that video games, which have been linked to childhood obesity [2,3], aggression, and poor school performance [4], can also be used in medical training. It has been proven that playing action video games enhances visuospatial attention and spatial resolution in a positive manner [5,6], and gamers have significantly better eye hand coordination than non-gamers [7]. Recently, there has been a rapid growth in studies suggesting that gamers have better baseline laparoscopic skills, and that video games could be used as a cost-effective and fun way to train basic laparoscopic skills in surgical residents. This article reviews all observational studies and controlled experiments directly related to the effects of video games on laparoscopic skills.

Methods

A search in the PubMed database was performed using the MeSH terms *video games*, *laparoscopy*, *general surgery* and *surgical procedures*, *operative*, and the general terms *eye hand coordination* and *psychomotor*. A complementary search, combining relevant terms for video games (*game*, *videogames*, *gaming*, *games*, *Nintendo,* and *Wii*) and laparoscopy (*laparoscopy*, *surgery*, *eye hand coordination*, *surgeon*, *psychomotor,* and *endoscopy*), was carried out as well. To broaden the search, the Embase database was consulted, looking for the same terms in titles, abstracts and index terms of all articles concerning human research. All available articles concerning video games and their effects on skills on any laparoscopic simulator (box trainer, virtual reality, and animal models) were selected.

Results

In total, 35 articles were found, out of which 19 studies were directly related to the subject of this paper. The remaining 16 articles were discarded because they were either other reviews or not directly related to the subject (e.g. focused on endoscopy or general surgery). The trials that assess the effects of video games on laparoscopic skills can be divided into two main groups. The first group of articles discusses the effect of video game experience on baseline laparoscopic skills. Thirteen observational studies investigated whether gamers have better baseline skills or not. The second group includes seven controlled experiments, in which video games have been used as an intervention to improve laparoscopic skills. One study covers both types of trials.

Game experience and basic laparoscopic skills

The influence of video game experience on laparoscopic simulator skills has been observed in a few studies that are specifically designed to investigate that goal. Grantcharov et al. were the first to describe a direct, positive relationship between video game experience and laparoscopic simulator score [8]. Subjects with previous game experience (10 out of 25 novice surgeons in training) made significantly less errors on the MIST-VR simulator (Mentice Medical Simulation, Gothenburg, Sweden), even after adjusting for gender and hand dominance. Shane et al. did a similar experiment; they found that students and residents who had previous game experience (11 out of 26) reached pre-set proficiency criteria significantly quicker after training [9]. This was, among others, based on a composite score including error rate. Recently, Kennedy et al. too showed that experienced gamers had better psychomotor abilities, using a ProMIS laparoscopic simulator (Haptica, Dublin, Ireland) [10].

Four studies have incorporated video game experience as one of many factors used to predict baseline laparoscopic skills [11-14]. Van Hove et al. followed 35 first-year surgical residents during their first year of training and correlated their initial laparoscopic skill level to trainee characteristics [11]. A history of video game use correlated with significantly higher scores and better skills retention. Madan et al., however, were unable to find any relationship between self-reported video game experience (non-gamer, novice, expert) and a subjective score in a porcine animal model [12]. Nomura et al. let 43 laparoscopic novices take a short questionnaire with nine independent variables, such a gender, confidence in driving skills and video game experience, before testing them on the ProMIS simulator [13]. Subjects that answered positively to the question “Do you like TV games?” were significantly faster and had a shorter left instrument path length. In an effort to predict the attainable proficiency level for first-time users of a virtual reality laparoscopic simulator, Paschold et al. studied 279 undergraduate medical students [14]. From a list of several expected, predictive factors such as age, sex, and handedness, frequency of playing video games (split into the terms “often”, “rarely” or “not at all”) was the only factor able to predict the first-time score on a laparoscopic simulator test after multiple logistic regression analysis.

Table 1: studies observing the effect of prior game experience on simulator skills

Article	Groups (n)	Game experience	Simulator used	Results
Paschold 2011 [14]	279 undergraduate medical students	Split into frequently, often, rarely or not at all	Two basic laparoscopic skills tasks on the VRL simulator (VR)	"Frequency of video gaming is associated with quality of first-time VRL performance"
Van Dongen 2011 [18]	(Non)gaming interns (10/10), (non)gaming kids (13/13)	"Average playing time of 10h per week"	Four tasks on the LapSim simulator were performed twice (VR)	Gaming interns scored significantly better then non-gaming interns. There was no difference between gaming children
Kennedy 2011 [10]	38 medical students	7 h/wk in 3 of the last 5 years	Psychomotor ability was measured using ProMIS (VR)	Regular gaming correlates with psychomotor ability.
Rosenthal 2011 [17]	Children (32), resident (20) and surgeons (14)	Questionnaire on experience (and frequency, years and genre for children)	Two physical tasks and one task on the Mentice SA simulator (box/VR)	Lowest performance was found in children with low experience, followed by those with high experience, residents, and surgeons with no significant difference
Fanning 2010 [16]	Teens (15) and Ob/Gyn interns (15)	Teens with 5 years of experience, interns without	Self-developed, validated, physical simulator (box)	Gaming teens were significantly faster on two out of three tests
Baburdeen 2010 [20]	Non-surgeons (20)	Total hours of non-Wii game experience	Validated, home-made simulator (box)	Game experience (non-Wii) predicts a better score on a laparoscopic simulator
Schlickum 2009 [15]	Surgical novices (45)	7-point scale for experience in different age categories	A task on the MIST-VR and the GI Mentor II (both VR)	Previous video game experience is positively correlated with performance in certain simulators.
Van Hove 2008 [11]	First year surgical residents (35)	Questionnaire on "current occasional participation"	MISTELS score before and after training and after one year (box)	Gamers scored significantly better on the first skills test, but not on the second and last ones
Shane 2008 [9]	Medical students (11) and surgical residents (15)	Have at one time played for 3h/wk on a regular basis	Two tasks on MIST-VR simulator (VR)	Gamers trained significantly quicker to proficiency criteria than other novices
Nomura 2008 [13]	Medical student, fifth year (43)	"Do you like TV games?"	1 physical task on the ProMIS simulator (VR)	The students who like TV games are quicker and their left instrument path is shorter
Rosser 2007 [19]	Surgeons (33)	Past or current game experience (≥3 h/wk)	Rosser Top Gun laparoscopic skills program (box)	Past and current video game experience correlates with laparoscopic skill
Madan 2005 [12]	First and second year students (67)	Self reported expert, novice or non-gamer	4 tasks in a porcine model (AM)	Video game experience does not predict baseline laparoscopy skills
Grantcharov 2003 [8]	Surgical residents (25)	"Previous computer games experience"	10 repetitions of 6 tasks on the MIST-VR simulator (VR)	Surgeons with computer game experience made significantly less errors

VR: Virtual Reality simulator, box: box trainer, AM: animal model, white: correlation, grey: no relation found

Besides a controlled experiment, as will be discussed in the next paragraph, Schlickum et al. used a detailed questionnaire to asses video game experience collected on different ages and found that participants who played games between age 14 and 18 scored significantly better on the MIST-VR laparoscopic simulator [15]. This correlates with an experiment done by Fanning et al., in which fifteen video game experienced teenagers (15-19 years) performed three laparoscopic tasks of which two were significantly quicker than fifteen first-year non-gaming residents in obstetrics and gynecology [16].

There were two studies in which younger children were observed [17-18]. Rosenthal et al. showed that children (aged 8 to 12) who don't play video games score lower on physical and virtual reality tasks than children who do, but this difference was not significant [17]. Van Dongen et al. also found that there was no significant difference between younger gamers (average 12.5 years) and non-gaming medical interns on performance on the LapSim simulator, although it turned out to be difficult to test children on a laparoscopic simulator [18]. They did, however, find that game experienced interns were significantly faster and more efficient than their non-gaming peers.

In only two observational studies video games were actually used to objectify video game experience [19-20]. Rosser et al. tested 33 surgical residents and attending physicians on three different video game consoles and their own laparoscopic skills and suturing program [19]. Both current (≥3 hours per week) and past gamers were faster and made fewer errors. When looking at demonstrated video game skill, subjects in the top tertile made fewer errors and performed faster. Baburdeen et al. performed a comparable experiment [20]. Not only did they show that participants who scored higher on the Nintendo Wii (Nintendo Co., Ltd., Kyoto, Japan) were better with a box trainer, but also that experienced (non-Wii) gamers scored higher on both the Wii and the box trainer.

Table 2: controlled experiments using games as an intervention to improve simulator performance

Article	Groups (n)	Intervention	Simulator used	Results
Boyle 2011 [24]	Students: Wii (11) vs. control (11)	A total of 3 hours in 1 week on the Wii	2 physical tasks, 1 VR task, both on ProMIS (box/VR)	Trend towards better performance after playing on the Wii
Plerhoples 2011 [23]	Laparoscopic novices: game (20) vs. control (20)	10 minutes with mobile game before testing on simulator	2 physical tasks on ProMIS (box)	Warming-up with a game prior to using a laparoscopic simulator decreases errors
Bokhari 2010 [25]	Interns: Wii (14) vs. control (7)	50 levels of Marble Mania with own Wii controller	Electrocautary task on ProMIS (box)	The Wii group was significantly more faster, proficient and made fewer errors
Schlickum 2009 [15]	Surgical novices: 3D game (15) vs. chess game (15) vs. control (10)	Five weeks of intensive, systematic video game training (Half Life, Chessmaster)	MIST-VR and GI Mentor II (both VR)	The group that played the 3D game scored better on both simulators; the chess game showed improvement on one simulator
Schlickum 2008 [26]	Surgical novices: FPS (11) vs. non-FPS (11) vs. control (4)	Five weeks of intensive, systematic video game training	MIST-VR and GI Mentor (both VR)	The FPS (first person shooter) group scored significantly better on the MIST-VR simulator
Sadandanan 2008 [22]	Ob/Gyn interns and students (30)	10-20 minutes of Super Monkey Ball using joystick	3 tasks on a pelvic trainer (box)	Playing video games improved laparoscopic skills and time to complete the tasks
Rosenberg 2005 [21]	Students: games (5) vs. control (6)	2 weeks to play any type of video game (avg. 6,2h)	4 laparoscopic tasks in a swine model (AM)	There was no difference between the game and control group after gaming for two weeks

VR: Virtual Reality simulator, box: box trainer, AM: animal model, white: positive effect, grey: no effect shown

Games used to improve laparoscopic skills

In 2005, Rosenberg et al. published the results of the first controlled experiment in which video games were used to improve laparoscopic skills [21]. Eleven medical students were randomized into two groups, after performing four different laparoscopic tasks in a swine model. The intervention group (n=5) played video games on an average of 6.2 hours during two weeks, while the control group (n=6) did not play any video games during this period. Afterwards, the tasks were repeated and the scores were evaluated. In contrast to the hypothesis, no correlation between video game training and changes in laparoscopic skills could be found.

Sadandanan et al. showed that one's skill on a box trainer would directly improve after playing 10 minutes of a console version of *Super Monkey Ball* (SEGA Corp., Ota, Tokyo, Japan), a popular balance game using a joystick [22]. Their study, however, lacks a control group. Plerhoples et al. used the similar game *Super Monkey Ball 2* for iPhone, in which real balance is used, as a warming-up prior to performing a laparoscopic simulator task [23]. Plerhoples did include a control group and stratified for previous game experience, and found that the group that warmed up using the video game made significantly less errors.

More recently, a Nintendo Wii version of *Super Monkey Ball*, which uses the motion sensitive Wii controller, was used by Boyle et al. to train laparoscopic skills in students [24]. After an intake session, in which two physical and one virtual reality task was performed on a ProMIS simulator, the students (n=11) played three hours of mini-games during one week. All three tasks were then performed for a second time and compared with a control group (n=11). Although practicing on the Wii was associated with a trend toward a better second performance, there was no significant difference.

A more intensive training program was developed by Bokhari et al., who used *Marble Mania* (*Kororinpa* in Europe and Japan, Hudson Soft Co., Ltd., Tokyo, Japan), a similar balance game for Nintendo Wii, in combination with a custom made Wii controller add-on that mimics a laparoscopic instrument [25]. A group of surgical residents (n=14) completed 50 levels of increasing difficulty directly before performing an electrocautery procedure on the ProMIS simulator. Compared to a control group (n=7), the trained residents took significantly less time, made fewer errors, and were more proficient in their hand movements.

Schlickum et al. performed two trials in which the effects of 2D and 3D games were evaluated [15,26]. It was hypothesized that visuospatially challenging video games, such as first person shooters (FPS), have a greater impact on laparoscopic skills. When playing these games, the player has to create a 3D image in his mind, while the action is perceived through a 2D representation on a monitor, similar to a laparoscopic procedure. In their pilot study, 26 surgical novices were tested on a laparoscopic (MIST-VR) and an endoscopic simulator [26]. Afterwards, the participants were matched and randomized into three groups: a FPS group (n=11), a non-FPS group (n=11) and a control group (n=4). The gaming groups played their specific game for half an hour, five days a week for five weeks and were then retested, together with the control group. The FPS group scored significantly better on the laparoscopic simulator than the group that had played a non-FPS game. Scores of the control group were not presented in the results section. In their second study, a similar experiment was performed using three groups: a *Half-Life* (Valve Software Corp., Bellevue, WA, United States of America) group (3D game, n=15), a *Chessmaster* (Ubisoft Entertainment S.A., Rennes, France) group (2D game, n=15) and a control group (n=10) [15]. Again, the same intensive training scheme was followed for five weeks. After retesting, the Half-Life and the

Chessmaster groups scored significantly better on the MIST-VR simulator than the control group, in which no significant improvement was found.

Discussion

There is evidence for a positive relationship between video game experience and laparoscopic simulator skills. This has also been found for endoscopy, which requires similar visuospatial abilities [15,26,32]. However, it should not be forgotten that the few studies providing this evidence are observational studies, which only show a correlation between laparoscopic skills and video game experience. Correlation does not imply causation. One theory, for example, is that innate dexterous people will be attracted to video games, because higher scores will be more rewarding for them [7]. Dexterous non-gamers have indeed proven to score better at a racing game than their colleagues [33]. This does not render the observational studies useless, since the positive effects have also been shown in controlled experiments.

Interestingly, when using video games as an intervention to improve laparoscopic simulator skills, there seem to be two totally different effects; a direct, warming-up effect and, on the long run, a learning effect. The warming-up effect can be seen directly after playing a balance game, with either a joystick or real balance (tilting a handheld computer), for about 10 minutes [22,23,25]. The long-term learning effect seems to kick in only after an intensive training program in which video games have to be played almost each day for several weeks [15,19,26]. Playing games for only a few hours during one or two weeks does not seem to have any significant effect on laparoscopic skills [21,24].

Currently, there is no standard definition for “video game experience”, nor is there a validated, standard questionnaire for previous or current experience. Rosser et al. have made the “The Amount of Video Game Experience Scale” for their own study, but did not publish their scale for further public use [19]. Other studies use totally different measures for game experience, such as total hours of game experience [20], self reported novice, expert or non-gamer [12] or whether one simply “likes TV-games” or not [13]. Van Dongen et al. defined video game experience as “an average playing time of at least 10 hours per week”, but failed to collect a group that does, with gaming interns playing an average of only 1.9 hours per week [18]. A good scale should not only account for the total hours of gameplay, but should also describe the distribution of these hours over a lifetime, since children have more free time to play video games than students, interns or surgeons. Schlickum et al. tackled this problem by letting participants score their game experience on a 7-point Likert scale (1 corresponded to never playing, 7 corresponded to playing every day) for current experience and between ages

1–6, 7–12, and 13–18 [15]. Because all studies use a different definition it is difficult to compare them on an equal level.

While most studies focus on current generation students and interns, some discuss the effect of video game experience gained on different ages [15-18]. It is still hard to evaluate the effect in current day surgeons, since the phenomenon of gaming developed later during their lives. It seems that younger gamers (≤12 years) do not score significantly better on laparoscopic simulators than their non-gaming peers, but experimenting with this age category seems quite challenging [17,18]. When comparing experience gained during puberty, however, a lasting, positive effect can be observed [15,16,18].

It should be noted as well, that almost all trials have used small research groups and have observed totally different parameters. While some studies only report that gamers are faster at laparoscopic tasks, others mention a shorter path length for tools or a better cumulative score. The various simulators owned by the research groups can explain this lack in uniformity. It is advised that further research on this subject is performed using a more standardized scoring system, such as the FLS peg transfer task [30,34].

Simulators have proven their usefulness in laparoscopy. However, they are expensive, mostly boring and not rapidly available. Video games, on the other hand, are cheap, could be used for teaching, and are preferred over lectures [35,36]. A competition with other peers also increases the motivation to voluntary join skills training [37]. The literature in this review has shown that video games could be part of a program for training basic laparoscopic skills in surgical novices. Senior surgeons may also benefit from video games, by using them as a warming-up prior to laparoscopic interventions. A video game, specifically designed to improve basic laparoscopic skills, could make virtual reality training cheaper and more fun [15,17,20,25,35]. Of course, video games can never replace true simulators and real operating room experience.

There is a correlation between playing video games and basic laparoscopic skills. However, the existing evidence is too weak to definitely establish the positive effects of gaming in the development of these skills. Till now, there is no validated scale or questionnaire to assess game experience, and neither do researchers use a uniform method to measure laparoscopic skills. Future trials should be more standardized and adequately powered, so stronger evidence on this subject can be acquired.

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