ORIGINAL ARTICLE

The Impact of Video Games on Training Surgeons in the 21st Century

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Background: Video games have become extensively integrated into popular culture. Anecdotal observations of young surgeons suggest that video game play contributes to performance excellence in laparoscopic surgery. Training benefits for surgeons who play video games should be quantifiable.

Hypothesis: There is a potential link between video game play and laparoscopic surgical skill and suturing.

Design: Cross-sectional analysis of the performance of surgical residents and attending physicians participating in the Rosser Top Gun Laparoscopic Skills and Suturing Program (Top Gun). Three different video game exercises were performed, and surveys were completed to assess past experience with video games and current level of play, and each subject's level of surgical training, number of laparoscopic cases performed, and number of years in medical practice.

Setting: Academic medical center and surgical training program.

Participants: Thirty-three residents and attending physicians participating in Top Gun from May 10 to August 24, 2002.

Main Outcome Measures: The primary outcome measures were compared between participants' laparoscopic skills and suturing capability, video game scores, and video game experience.

Results: Past video game play in excess of 3 h/wk correlated with 37% fewer errors ($P<.02$) and 27% faster completion ($P<.03$). Overall Top Gun score (time and errors) was 33% better ($P<.005$) for video game players and 42% better ($P<.01$) if they played more than 3 h/wk. Current video game players made 32% fewer errors ($P=.04$), performed 24% faster ($P<.04$), and scored 26% better overall (time and errors) ($P<.005$) than their nonplaying colleagues. When comparing demonstrated video gaming skills, those in the top tertile made 47% fewer errors, performed 39% faster, and scored 41% better ($P<.001$ for all) on the overall Top Gun score. Regression analysis also indicated that video game skill and past video game experience are significant predictors of demonstrated laparoscopic skills.

Conclusions: Video game skill correlates with laparoscopic surgical skills. Training curricula that include video games may help thin the technical interface between surgeons and screen-mediated applications, such as laparoscopic surgery. Video games may be a practical teaching tool to help train surgeons.

Arch Surg. 2007;142:181-186

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SALES IN THE VIDEO GAME INdustry approached $10 billion in the United States in 2002.[1] Of adolescents, 94% play video games for an average of 9 h/wk (13 h/wk for adolescent boys),[2] and many of the same people who began playing video games in the 1980s have continued to play, making the average age of a video gamer 29 years old.[3] Widespread Internet use and increasing bandwidth availability have facilitated cooperative play for individuals worldwide, thereby further increasing video game popularity. Video games have become an integral part of the daily lives of nearly 2 generations of Americans. The possible effects of video games have received considerable attention in the general media and in the scientific literature.

See Invited Critique at end of article

Disturbing negative correlations with video game play include lower grades in school[2]; aggressive thoughts, emotions, and actions (including physical fights); and decreasing positive prosocial behaviors.[2] Excessive game playing has also been linked to childhood obesity,[4] muscular and skeletal disorders,[5,6] and even epileptic seizures.[7] Other physical findings have included increases in blood pressure, heart rate, and stress hormones (norepinephrine and epinephrine)[8,9] (also P.J.L. and

Laury Haskamp, MD, unpublished data, 2003). However, positive benefits of video game play include increased performance on eye-hand coordination tasks and neuropsychological tests and better reaction time, spatial visualization, and mental rotation.[10-14]

A recent study[15] assessed video gaming enhancement of visual attention (eg, increased ability to process information over time and an increase in the number of visual items that can be apprehended) and its spatial distribution (eg, enhanced allocation of spatial attention over the visual field). A positive correlation was found between video gaming and visual attention processing, and a correlation with competence in analogous tasks was suggested.

Video games that require interaction with virtual reality situations—simulator training—can potentially lead to acquisition of complex real-life skills, such as driving,[16] flying airplanes, and even playing golf.[17] Skill transfer does not require force feedback if visual information compensates. An example of this was seen in a study of 62 right hand–dominant men (mean age, approximately 20 years) with no previous golf experience. The participants were divided into 5 groups (after controlling for visual imagery abilities): 1 control group, 2 learning groups (with the intent to improve in actual putting), and 2 enjoyment groups (with the intent to simply enjoy the game). The results indicated that the 2 learning groups showed the most improvement in golf putting. All 4 of the experimental groups improved their posttest scores, demonstrating that video games can be an effective skill transfer tool, even without haptic references, particularly if a user is engaged in a skill-learning strategy.[17]

Detailed scrutiny of physician training has been increasing greatly in surgery, especially with the introduction of laparoscopic surgery. The traditional medical model of "see one, do one, teach one" is no longer adequate to train physicians, because many skills cannot be developed by merely watching an expert.[18,19] Subsequently, during the early adoption phase of new procedures, a "learning curve" is encountered. During this introductory period, the risk of complications and deaths is the highest. Medical errors have become the eighth leading cause of death in this country—as many as 44 000 to 98 000 per year—with an estimated cost of \$37.6 billion per year.[20] A variety of approaches teach procedural skills with the focus on error prevention. Artificial tissues are useful for skill development, but the scope of activities that can be learned from their use is limited.[21] Simulator training in technique building for laparoscopic surgery,[21,22] colonoscopy,[23] sinus endoscopy,[24] and trauma has been effective.[25] Simulator techniques have been successful in the military and aerospace industries, focusing on training, performance enhancement, and error prevention.[26] Over-the-counter video games may constitute a training resource, not as simulation but as a gradual path of analogous or parallel skill acquisition.

It has been suggested that younger surgeons may acquire skills in laparoscopic surgery more rapidly than their elder colleagues, possibly because they have been exposed to video games at a young age and, thus, have had more experience with screen-mediated task execution.[27] Other studies[27,28] have shown that subjects with previous regular engagement in video game play tend to be more skillful at videoendoscopic surgical tasks. Video games are frequently a person's first contact with a graphical user interface. Therefore, they could promote familiarity with other screen interfaces, such as those used in laparoscopic surgery. This study correlates participant performance in video games with laparoscopic surgical skills.

METHODS

Thirty-three surgeons (21 residents and 12 attending physicians; 15 men and 18 women) from Beth Israel Medical Center participated in this study. Their specialties included general surgery (n=22), urology (n=2), and obstetrics/gynecology (n=9). The right hand was dominant in 30 surgeons, and the left hand was dominant in 3 surgeons. The attending physicians had 12.9 years of surgical experience, and the residents, 3.1 years. The mean number of laparoscopic cases performed by attending physicians was 239; and by residents, 46.

The study design centered on the Rosser Top Gun Laparoscopic Skills and Suturing Program (Top Gun),[22] and data were gathered from May 10 through August 24, 2002, at Beth Israel Medical Center. The goal of Top Gun is to build skill sets that enable surgeons to function effectively in the videoendoscopic surgical environment. In addition, it teaches surgeons intracorporeal suturing, perhaps the most challenging task in laparoscopy. Top Gun has been featured in the scientific section of the American College of Surgeons' annual convention since 1996 and in the Society of American Gastrointestinal Endoscopic Surgeons' and the Society of Laparoscopic Surgeons' congresses. Thousands of trainees worldwide have validated the course for advanced skill acquistion.[23]

This study consisted of 3 elements, and each subject participated in all elements. Element 1 consisted of a questionnaire to assess video game play, surgery experience, and other demographic information, including age, sex, and hand dominance. The video game portion of the questionnaire asked questions pertaining to episodes of play, length of time playing, types of games played, and familiarity with specific genres of games. The surgical experience portion assessed the subjects' level of training or years in practice, number of laparoscopic cases performed, and subspecialty. This element of the study occurred at the orientation of Top Gun, before any video games or surgical drills had begun.

Element 2 was Top Gun itself, which was conducted over 1½ days. The Top Gun basic skills and intracorporeal suturing courses involve preparatory laparoscopic drills and interrupted suturing on porcine bowel. The preparatory drills emphasize nondominant hand dexterity, 2-handed choreography, 2-dimensional depth perception compensation, and targeting. The first drill is the Cobra Rope Drill, requiring participants to unwind and pass a string using 2 standardized laparoscopic graspers, targeting specific colored sections of the string. The second drill is the Terrible Triangle Drill, which involves lifting and moving 5 triangular objects from one designated point to another by placing a needle through a metal loop atop each triangle, using an instrument with the nondominant hand. The third drill is the Cup Drop Drill, during which participants move beans from a designated area into a cup with a 1-cm aperture using a standard laparoscopic grasper in the nondominant hand. Last, interrupted sutures are placed into porcine intestine. This complex task is executed using a standardized technique algorithm. The time to complete each task is recorded, and an electronic proctor registers and tabulates errors committed by inaccurate instrument movements. These variables serve as a measure of performance. The course has been previously described in detail.[21]

Element 3 consisted of playing 3 over-the-counter video games. Subjects were taken in groups of 3 for 25 minutes of video game play. All participants completed all 3 elements. Of the 33 subjects, 8 completed the video game tasks after having participated in Top Gun between 12 and 24 months previously. These 8 participants were not selected and were not members of the original study group. All other participants completed all elements at the same time. Participants were given a standard set of instructions and a brief demonstration and then asked to begin play.

Three representative games were selected from 100 of the most popular video games. Each game was chosen based on its applicability to the development of specific skills required for completion of Top Gun. The skills tested by these games included fine motor control, visual attention processing, spatial distribution, reaction time, eye-hand coordination, targeting, nondominant hand emphasis, and 2-dimensional depth perception compensation. Games were also selected based on their ease of measurement and lack of bonus scores, which could skew data away from the mean, thus creating a nonrepresentative bimodal distribution of scores. Therefore, 2 games were scored purely as total time to complete, while the third measured total targets hit. Sex neutrality and game novelty were also selection criteria. None of the subjects had ever played any of the 3 video games used for this study.

The first video game was *Super Monkey Ball 2* (Sega of America Inc, San Francisco, Calif) for Nintendo Gamecube (Nintendo Co Ltd, Tokyo, Japan). The player pilots a spherical ball around a dynamic undulating course while targeting specific items. Performance was scored by total time to complete the course. If the course was not completed in 300 seconds, a value of 300 seconds was assigned.

The second video game was *Star Wars Racer Revenge* (LucasArts Entertainment Company, San Rafael, Calif) for Sony PlayStation 2 (Sony Computer Entertainment, Inc, Tokyo), in which players navigated a serpentine canyon track, competing against 5 other computer-controlled racers. The score was total time to complete a single lap. All games were viewed on either a 51-cm television monitor or a 46-cm flat screen monitor (Trinitron; Sony Corporation, Tokyo), such as those used in laparoscopic surgery.

The third video game selected was *Silent Scope* (Konami Co, Tokyo) for Microsoft Xbox (Microsoft Corp, Redmond, Wash), which required the player to shoot as many screen targets as possible in 2 minutes 30 seconds. The score was the total number of targets hit.

A composite video game score averaged the 3 standardized video game scores. Participants' scores from playing the 3 video games were reversed such that higher numbers were indicative of better play. The video game skill scale was reliable as measured by the Cronbach α (α=.81).

The Amount of Video Game Experience Scale was created in a similar fashion. Participants' self-reported responses to 5 items measuring past and present involvement in video games were scored such that higher numbers were indicative of greater involvement and then were standardized. The Amount of Video Game Experience Scale was created by averaging the 5 standardized items. This scale was reliable as measured by the Cronbach α (α=.90).

RESULTS

Top Gun scores were grouped according to video experience analyzed and compared based on 3 criteria: (1) "current player" (participants who play video games based on survey responses), (2) "past player" (those who had played video games at some point in the past based on survey responses), and (3) those participants with "demonstrated skill" as measured in the video games outlined previously. These criteria were then compared with participants who had never played video games ("nonplayer" based on survey responses).

PAST VIDEO GAME PLAY EXPERIENCE

Of the surgeons, 19 (58%) reported playing video games at some point in the past, while 14 (42%) reported never playing. Those who reported playing video games in the past were asked how often they played video games at the height of their gaming. Of the surgeons, 10 (30%) reported playing almost every day. Participants reported having played for a mean of 8.0 years (SD, 10.2 years). At the height of video game playing, 5 (15%) played between 0 and 1 h/wk, 4 (12%) played between 1 and 3 h/wk, 1 (3%) played between 3 and 5 h/wk, 5 (15%) played between 5 and 10 h/wk, 2 (6%) played between 10 and 15 h/wk, and 1 (3%) played more than 15 h/wk. Men were historically more likely to play video games frequently ($t_{31}=2.59$, $P=.02$). Men were also more likely to have spent more hours per week playing than women ($t_{31}=38.5$, $P=.001$).

Analyses of variance compared surgeons who had never played video games in the past, those who reported playing 0 to 3 h/wk, and those who reported playing more than 3 h/wk at the height of their playing. These categories were determined empirically, attempting to have approximately equal numbers of surgeons in each group (15, 9, and 9, respectively). The analyses of variance were conducted to test differences between surgeons with different amounts of play on time to complete Top Gun drills and the number of errors. Significant differences emerged for time ($F_{2,30}=4.1$, $P=.03$) and errors ($F_{2,30}=3.9$, $P<.03$). Post hoc Bonferroni tests showed that the significant effects are because of the difference between the surgeons who never played video games and those who played more than 3 h/wk. Surgeons who never played video games took more time to complete the Top Gun drills (5224 seconds) than surgeons who played 0 to 3 h/wk (4135 seconds) or those who played more than 3 h/wk (3802 seconds), although only the difference between the 2 extreme groups was significant ($F_{2,30}=4.1$, $P=.03$). Surgeons who never played video games also made more errors in the Top Gun drills (314 errors) than surgeons who played 0 to 3 h/wk (257 errors) or those who played more than 3 h/wk (197 errors), although only the difference between the 2 extreme groups was significant ($F_{2,30}=3.9$, $P=.03$). Overall, the Top Gun scores (time and errors) of surgeons who played video games in the past were 33% better ($t_{31}=-3.04$, $P<.005$). If the surgeons were past players who played more than 3 h/wk, they had an overall Top Gun score that was 42% better than the non–video gaming group ($P<.01$).

CURRENT PLAYER VIDEO GAME PLAY EXPERIENCE

Of the surgeons, 12 (36%) reported currently playing video games, averaging 19.0 minutes (SD, 32.8 minutes) at one sitting. Men were more likely to play video games frequently ($t_{31}=3.15$, $P<.01$), and had been playing for significantly more time than women (mean, 14.2 and 2.1 years, respectively; t_{31}=4.18, $P<.001$). Men were more likely to spend more hours per week playing than women (χ^2_3=8.4, P=.04).

The differences between current video game players' and nonplayers' laparoscopic skill and suturing scores were evaluated. Current video game players made 32% fewer errors (t_{31}=2.2, P=.04) and performed 24% faster (t_{31}=2.2, $P<.04$) than their non–video game–playing colleagues. If they were current players, they scored 26% better overall (time and errors) on Top Gun (t_{31}=−3.04, $P<.005$).

DEMONSTRATED VIDEO GAME SKILL

Each of the video games used to quantify the subjects' demonstrated video game skill was highly correlated with laparoscopic skill and suturing ability. *Super Monkey Ball 2* showed the highest correlation (r=0.63, $P<.001$), followed by *Silent Scope* (r=0.50, P=.003) and *Star Wars Racer Revenge* (r=0.48, P=.004). An overall video game skill scale was also created as previously described, which was also highly correlated with laparoscopic skill and suturing ability (r=0.63, $P<.001$). Demonstrated video game skill as a predictor of laparoscopic skill and suturing scores was studied. This was done by dividing the participants into tertiles based on their demonstrated video game skill on the 3 video games. When comparing the subjects from the top tertile with those from the bottom tertile, subjects in the top tertile made 47% fewer errors ($F_{2,30}$=10.0, $P<.001$), performed 39% faster ($F_{2,30}$=11.9, $P<.001$), and scored 41% better ($F_{2,30}$=15.5, $P<.001$) in their overall Top Gun score.

REGRESSION ANALYSIS PREDICTING LAPAROSCOPIC SKILLS

A regression analysis was performed to test further the relationship between laparoscopic skills and demonstrated video game skills and past video game experience. The first 3 demographic variables (years of training, number of laparoscopic cases, and sex) did not predict a significant amount of variance in Top Gun scores. However, amount of past video game experience (β=−.11, P=.03) and demonstrated skill (β=−.76, $P<.001$) predicted a significant amount of variance in Top Gun scores after controlling for sex, amount of training, and number of laparoscopic cases completed (note that lower Top Gun scores are better).

The relative weight analysis of Johnson[29,30] was conducted to determine the relative importance of each of the predictors. Relative weight analysis estimates the proportionate contribution each predictor makes to the overall variance while considering its unique contribution and its contribution when combined with other variables.[29] Of the individual variables, demonstrated video game skill accounted for the greatest amount of variance (31%) and amount of past video game experience accounted for an additional 10% of the variance. The number of laparoscopic cases performed and the surgeon's sex accounted for 2% of the variance, and years of training were unrelated to demonstrated laparoscopic skill (0.3%) as determined by Top Gun. A total of 55% of the variance was unknown.

COMMENT

Surgeons who had played video games in the past for more than 3 h/wk made 37% fewer errors, were 27% faster, and scored 42% better overall than surgeons who never played video games. Current video game players made 32% fewer errors, were 24% faster, and scored 26% better overall than their nonplayer colleagues. All 3 video games used in this study were highly correlated with laparoscopic skills. Furthermore, when comparing demonstrated video game skills, those in the top tertile made 47% fewer errors, performed 39% faster, and scored 41% better ($P<.001$ for all) on the overall Top Gun score. Consistently throughout this study, past, current, and demonstrated video game skill not only increased speed but also decreased errors. It is the error reduction that will have the most significant effect on patient safety.

Regression analysis suggested that past and current video gaming capabilities were more important than traditionally recognized factors, such as years of training and number of laparoscopic cases. The amount of time playing video games in the past was also a significant predictor of demonstrated laparoscopic skill.

This is a correlational study and, therefore, causality cannot be definitely determined. It is possible that the possession of laparoscopic skills may improve video game performance. But, it is clear that the surgeons tested were not superiorly skilled in advanced laparoscopic surgery. It is likely that video game skills are a better predictor of demonstrated laparoscopic skills and suturing than years of experience with laparoscopy because many laparoscopic procedures do not require the advanced skill sets as measured in the course.

There is ample evidence to suggest that games with certain design characteristics and focused duration of exposure can execute predetermined participant effects.[2,31,32] The amount and content of video game play have been studied and found to have significant effects on behavior and performance.[8,9,33-39] As argued elsewhere,[40,41] it is also likely that the form and mechanics of video games can have important effects, and that they are more likely (than amount or content) to be the mechanisms by which video gaming may improve laparoscopic skills. The formal features that define video game play include aspects of game design, such as amount of visual attention needed and reaction time that is required to perform well. To the extent that games can be designed with specific formal features, it is possible that the effects on users could be tailored to specific dimensions. The use of task-related mechanics for game controllers can also produce positive effects (eg, driving simulators with a steering wheel should transfer better than steering with a computer mouse). Theoretically, game controllers could be designed so that they resemble laparoscopic instruments and other medical appliances. In addition to over-the-counter video games being used in surgical education, video games in the future could be created with specific game forms and mechanics, content, and playtime constructs that coordinate directly with the development of medically related fine motor skills, eye-hand coordination, visual attention, depth perception, and computer competency.

Video games have been accepted and have become an integral part of US and global culture. They are relatively inexpensive, portable, and reliable. Video game play has been incorporated into training by industries and organizations in which routine training scenarios are too dangerous or expensive. The US Army has recognized the benefits of video games for teaching skills, and has licensed the popular violent video game series *Rainbow Six* to train its special operations forces because it is an excellent way to teach all of the steps necessary to plan and conduct a successful special-operations mission.[29] Hopefully, in a similar fashion, medicine can tap into the training and technology conditioning capability of video games.

The results of this study are highly significant and invite creative inclusion of video game play as an adjunct for skill training in laparoscopic surgery. Although surgeons who played the most video games in the past demonstrated better speed and accuracy, the significant amount of gaming time demonstrated in this study was 3 h/wk or more at the peak of play. This is greatly less than the average for today's adolescents, who average 9 h/wk (13 h/wk for adolescent boys and 5 h/wk for adolescent girls).[2] Furthermore, research on the amount of gaming has shown a negative correlation with school performance for adolescents and college students.[2,32] Therefore, indiscriminate video game play is not a panacea.

Although video game play was more likely to be a pursuit for men rather than women, correction for actual game playtime showed there was no sex difference in skill acquisition. Video game design could be a strong element in recruiting young people to a surgical career. It could also accomplish a similar effect on other professions that require eye-hand coordination and spatial awareness. Given the broad and sustained appeal of video games, it seems reasonable to explore their positive aspects in the interest of education, skill acquisition, and skill maintenance.

Accepted for Publication: December 28, 2005.
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Financial Disclosure: None reported.
Disclaimer: The views expressed herein are solely those of the authors.

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Invited Critique

The idea that video game playing improves laparoscopic skills is appealing. Now kids and guilty parents do not have to argue about the electronic babysitter—this is an investment in the children's future! This is a seductive idea that has enormous potential for distortion by the media and public. The most important statement in this article is found near the end: "indiscriminate video game play is not a panacea." We still have to watch our children's video gaming carefully—the number of hours, the types of games, and so on. And will it really improve laparoscopic skills? There are several problems with this article. First, the small sample size leaves significant potential for bias. Second, the authors suggest that we should include video game play for laparoscopic skill training, but their data suggest that past playing is what improves laparoscopic skills. They did not determine the formative years during which video game playing will improve laparoscopic skills. If those skills are best developed from the age of 8 to 15 years, then video game play during residency is fruitless. The authors also suggest that video game playing decreases errors during Top Gun, which could improve patient safety. There is no analysis of the seriousness of those errors. We all know that many errors do not result in patient harm. This study does not indicate that good Top Gun scores decrease deaths or increase patient safety. Equally important, high Top Gun scores do not correlate with competency, and we do not know if video game playing leads to competency in laparoscopic skills. One could argue that a competent laparoscopic surgeon with lower Top Gun scores who has superb judgment, great interpersonal skill, and outstanding communication skills is a better physician than a competent laparoscopic surgeon with high Top Gun scores who has no interpersonal or communication skills because of spending so much time isolated playing video games. The lesson to be learned from this article is actually quite focused. We should consider using video games as another tool to help surgeons reach competency. Perhaps those surgeons with a demonstrated skill in video gaming or with significant past playing could use video games to help learn laparoscopic skills, while those surgeons with little to no skill in video gaming should use other learning modalities to become competent laparoscopic surgeons. Although it seems intuitive that video game skills can translate to improved laparoscopic skills, further studies are needed before we include video game play as an adjunct for skill training in laparoscopic surgery or before we relax our concerns about video game playing among children.

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Financial Disclosure: None reported.