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ORIGINAL ARTICLE

Serious gaming and voluntary laparoscopic skills training: A multicenter study

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Abstract

This study assesses the issue of voluntary training of a standardized online competition (serious gaming) between surgical residents. Surgical residents were invited to join a competition on a virtual reality (VR) simulator for laparoscopic motor skills. A final score was calculated based on the task performance of three exercises and was presented to all the participants through an online database on the Internet. The resident with the best score would win a lap-top computer. During three months, 31 individuals from seven hospitals participated (22 surgical residents, 3 surgeons and six interns). A total of 777 scores were logged in the database. In order to out-perform others some participants scheduled themselves voluntarily for additional training. More attempts correlated with higher scores. The serious gaming concept may enhance voluntary skills training. Online data capturing could facilitate monitoring of skills progression in surgical trainees and enhance (VR) simulator validation.

Key words: *Serious gaming, training, laparoscopic surgery, skills, virtual reality, minimally invasive surgery*

Introduction

The worldwide adoption of laparoscopic surgery in the daily surgical practice has demonstrated that training solely according to the traditional apprenticeship model and learning on the job was no longer acceptable (1,2). Learning is associated with making mistakes that could harm patients. The awareness that structural training in a safe environment is required prior to embarking on real patients led to a paradigm shift in surgical skills training (3).

Nowadays, some training hospitals have adopted skills labs and various simulation models to train laparoscopic motor skills. Virtual reality (VR) simulators offer trainees unlimited practice, adjusted to their level of skill, in a safe environment without any risks for patients. In addition, computer-based simulation is able to generate objective outcome parameters which can be used for monitoring performance and progress. However, laparoscopic skill training remains a challenge in surgical education. It is reported that voluntary use of a simulation lab leads to minimal participation (4). The most common reasons expressed for lack of voluntary participation were lack of time and interest. However, deliberate practice is essential for developing skills beyond normal ranges, even for the experienced subjects. This has been shown by Ericson for the domain of professional musicians and top-athletes (5,6).

In order to boost deliberate practice and overcome the motivational barriers we introduced the concept of "serious gaming" in the field of simulator training

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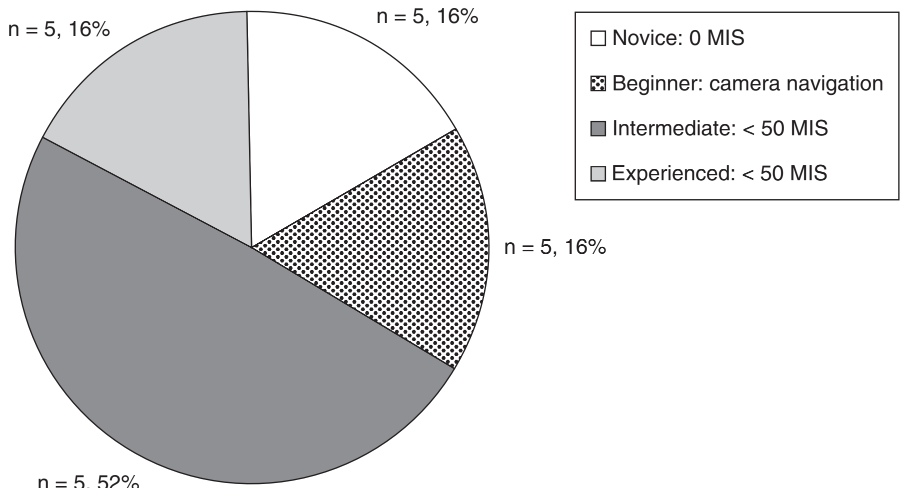

Figure 1. Distribution of participants according to experience with laparoscopic surgery

by introducing a skills competition and a reward for the best performance. There is no single definition for serious games. In general, they cover a broad spectrum of computer-based simulations for training or education in a single or multi-user environment. Serious games are intended to provide an engaging, self-reinforcing context motivating and educating its users. The games often simulate only a part of the real world and realism is not the most important aspect. Serious games are used in various domains such as the military, police, aviation and ship navigation to train personnel in a challenging way (7 – 10). Today, numerous examples can be found on the internet. In surgery, computer-based simulations are commonly used for laparoscopic skills training, but the potential benefits of a competition have not yet been investigated. The competition element may tackle the voluntary training problem in laparoscopic motor skills training.

In order to induce deliberate practice, the aim of this study was to evaluate the serious gaming effect with an online competition between surgical residents on a laparoscopic VR simulator.

Material and methods

Hospitals in the Netherlands were invited to join an online competition with the VR simulator SIMENDO (Delltatech, Rotterdam, the Netherlands). The simulator aims specifically at eye-hand coordination training essential for laparoscopic surgery and employs abstract tasks without force feedback. Previously, several studies proved the simulator had face and construct validity for laparoscopic motor skills training (11,12). The simulator showed to be able to differentiate between groups with different levels of experience (11).

The competition consisted of three tasks: Pile cylinders, 30° endoscope manipulation and drop the balls with boxes. The tasks are short exercises of several minutes, one to four minutes. Time needed to complete all the tasks depends on experience with laparoscopic surgery and skills training. Normally, these tasks can be performed separately on the simulator (SimSoft 2.0), but for this study they were modified into a "competition module" and had to be performed in a consecutive order. Performance measurement was based on task-time, instrument path length, collisions with non-target environment and errors. The lower the task-time, path length, collisions and errors, the higher the score for each task with a maximum of 10.000. The final score was the calculated average of all three tasks. The final score was automatically sent to an online database (VREST, Enschede, the Netherlands) and directly presented to all the participants on the simulator. The simulator had to be connected to the Internet. The participants received a password by e-mail that allowed them to access the database from any computer connected to the Internet. The database application for the final score presentation was especially built for the study.

To enter the competition, the contestants had to complete a short online registration form and fill out a digital questionnaire concerning age, gender, experience with minimally invasive surgery (MIS), surgical specialty and their motivation to participate. Experience with MIS was defined as performing any laparoscopic procedure. There were four categories:

- no experience,
- camera navigation experience,
- intermediate experience defined as performed less than 50 laparoscopic procedures and

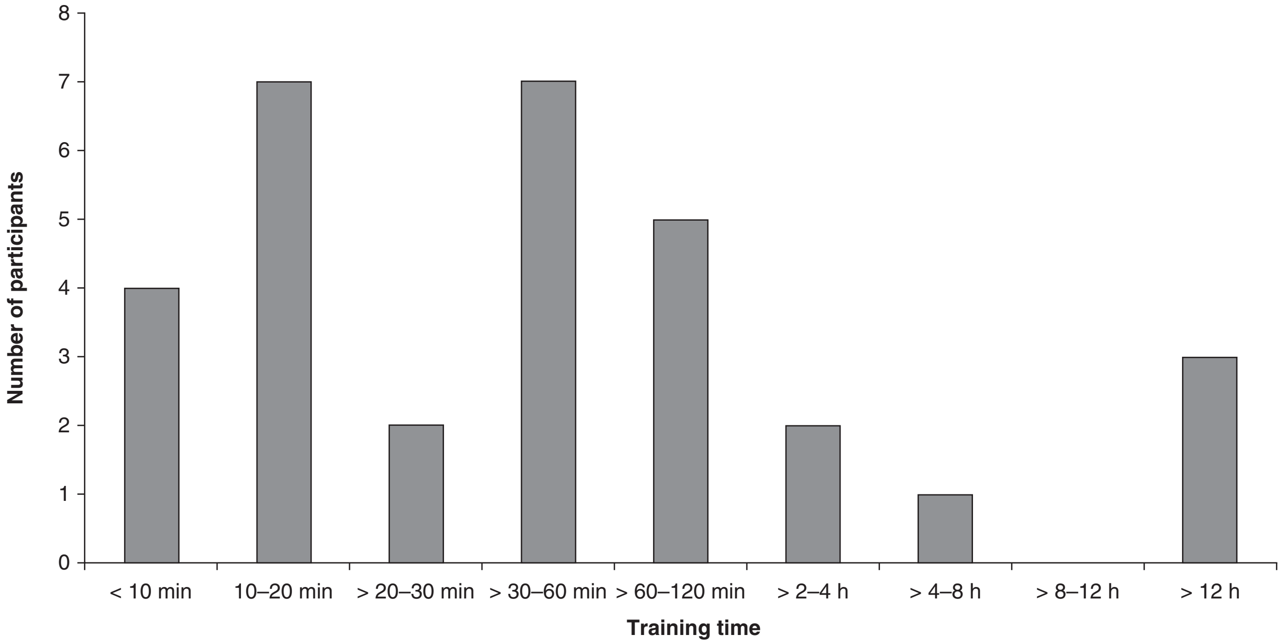

Figure 2. Number of participants by amount training time on the simulator

- experienced participants that had performed more than 50 procedures.

Concerning the motivation of the participants we asked why they joined the competition. Participants had to choose one out of four options were provided:

- for fun,
- they felt obliged,
- to learn laparoscopic motor skills, or
- to win the competition.

We asked also to rate their motivation to learn laparoscopic motor skills expressed on a scale from 1 (none) to 10 (enormous). Furthermore, participants gave their consent that the data could be used for research. The competition and the preset end date were promoted through short presentations in each participating hospital, posters and press releases. All potential participants were allowed to enter the competition till the end date. The number of attempts per contestant was unlimited. The surgical trainee with the best performance score could win a lap-top computer.

Statistical analysis

The data were analyzed with the Statistical Package for the Social Sciences version 12.0 (SPPS, Chicago, IL) using nonparametric tests. Comparison between performances of groups was undertaken using the Mann-Whitney U Test. A level of $P < 0.05$ was considered statistically significant.

Results

Between December 2006 and February 2007, seven hospitals participated: Three academic training centers, four large regional training hospitals. Thirty-one contestants participated: 22 surgical trainees, three surgeons, six interns; there were 23 men (75%) and eight women (25%). The median age was 30 years (range, 23 – 56 years). The highest score was 9.88 with 105 attempts and the lowest score was 1.23 with only one attempt. Altogether, the participants trained 79 hours and 20 minutes with a median of 53 minutes (range, 4.4 minutes – 19 hours and 4.5 minutes). Figure 1 displays a pie diagram of the experience with minimally invasive surgery in four categories. Sixteen participants (52%) had performed more than one and less than 50 procedures. Figure 2 shows the number of participants by amount of training time on the simulator.

A total of 777 attempts with a final score were registered in the database. Median number of attempts per participant was six (range, 1 – 212 attempts). Figure 3 shows the median of the scores by the attempts. There were only five participants who performed more than 22 attempts.

The final score (the highest score a participant reached) was compared with the number of total attempts, a higher final score was associated with a higher number of attempts. Figure 4 shows box plots of the final score versus number of attempts for four groups. More than 30 attempts resulted in a significantly higher final score than that reached

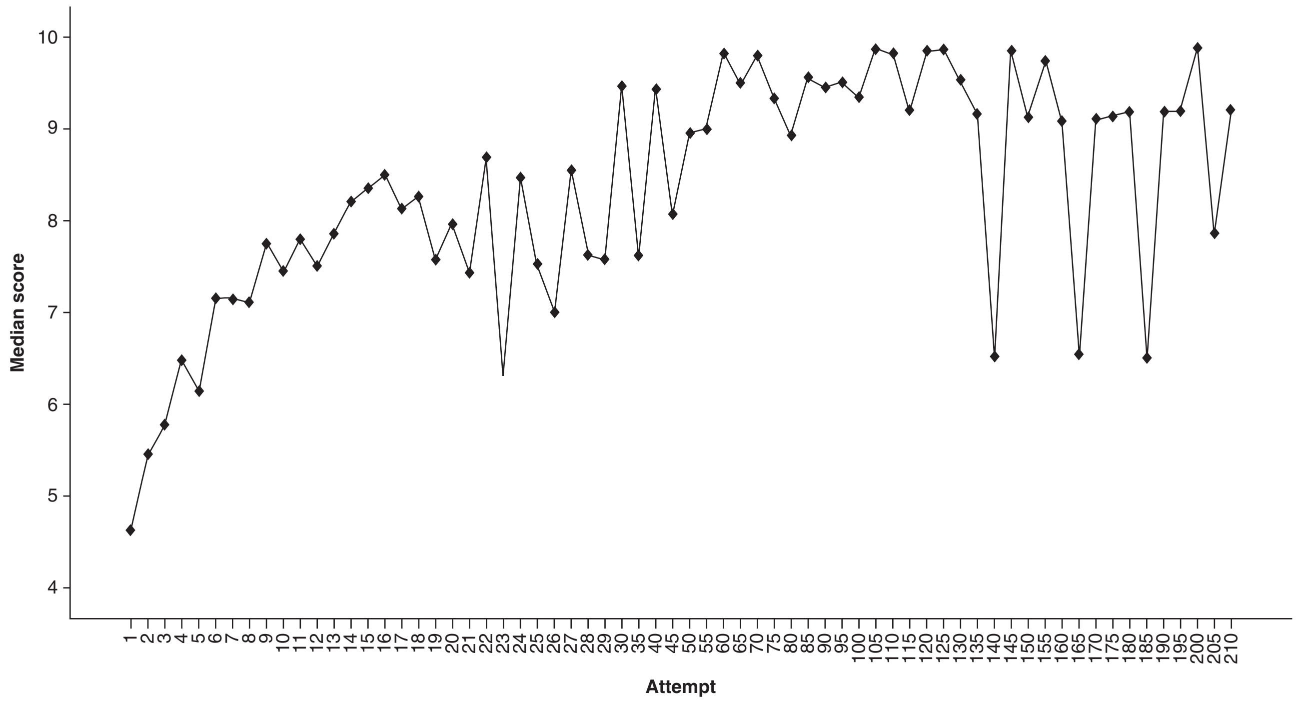

Figure 3. Median scores and attempts

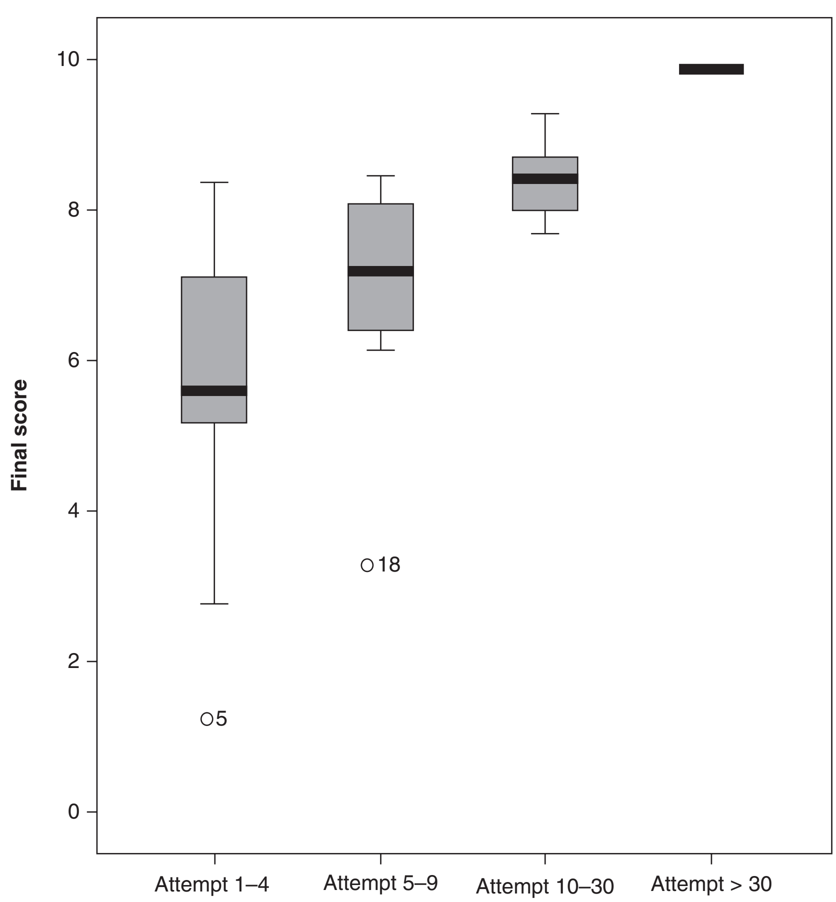

Figure 4. Final score and attempts

by participants who performed between ten and 30 attempts (Mann-Whitney U test, P = 0.008). There was also a significant difference for the final score between the other groups, except between participants that performed less than four attempts and the group that performed between five and nine attempts (P = 0.135).

Figure 5 shows a bar diagram of the number of participants for each center. Center "C" and center "G" entered the competition four weeks later than the others because of technical and organizational difficulties with the internet facilities.

When asked for their motivation to participate in the competition, more than 50% of the contestants stated they wanted to win. The median score of motivation to learn laparoscopic skills as expressed on a scale from 1 (none) to 10 (enormous) was 9 (range, 1 – 10). The motivation score did not correlate with the final score on the simulator (Pearson Correlation Coefficient was 0.331, p = 0.088)

Discussion

To our knowledge this is the first study undertaken to explore the effect of a multicenter, online competition with a VR simulator. The term of serious gaming is relatively new in the surgical field and is meant to underline the competition element, engaging features of training and the fact that there was a price to win in addition to existing laparoscopic simulation. The competition on the VR simulators led to deliberate practice and enthusiastic reactions of the participants. In addition, we showed that it is feasible to gather data generated by VR simulators for laparoscopic skills training through an online database.

In the past decade, several VR simulators for laparoscopic skills training have been developed and validated (13). Studies show that they can reliably asses the skills that are essential for laparoscopic surgery and improve the performance of trainees in real procedures (14,15). This effect may further be enhanced by introducing challenging or expert-based performance goals (16,17). Currently, training criteria for several simulators have been determined (18,19). The usual consequence of passing these criteria is that the trainee is allowed to proceed to more advanced training models or to perform surgery on patients. However, results from a study with dual task training in which a laparoscopic suturing task had to be performed simultaneously with another visual task showed that experts and simulator-trained individuals outperformed trainees with procedural experience (20). These results suggest that skill training goes beyond predefined performance levels and would take much longer than most believe. Hence, extensive training seems to be justified. Nevertheless, with the recently reduced workweek for medical trainees there is a problem to fit additional training into a busy training program. Additional training should ideally take place on a voluntary basis, enabling trainees to practice at their own convenience. Furthermore, deliberate practice may enhance skills retention for a longer period (6). Deliberate practice on simulators in a skills laboratory is difficult, especially for trainees with procedural experience. Motivation is an important, often underestimated, factor in learning new skills and ongoing training.

According to Hutchinson (21) the motivation to learn can be intrinsic (from the trainee) and extrinsic (from external factors). Extrinsic factors are exams, assessments, promotion, financial profits, prolonging registration etc. Intrinsic factors are motivators such improvement of personal achievement (improvement of skills and knowledge), be prepared for new situations, security, but also fun and competition. We can not separate these factors in our study. However, the price to win was an extrinsic factor but the desire to achieve and to win the competition was an intrinsic factor. Both can be considered to enhance deliberate practice. However, one can speculate whether such competition is an attractive factor for everyone.

There are some limitations of this study. There was a remarkable difference in the percentage of participating residents between the centers. This can partly be explained by the fact that two centers entered the competition later than others due to some technical and organizational difficulties with the internet facilities. Furthermore, in each center it took several weeks before the competition really started and three centers provided clearly less participants than others. The teachers, also mentioned by Hutchinson (21), may have played a role. The enthusiasm of the staff and their periodic encouragement of trainees to join the competition could explain the difference between the centers for a large part. Most of the participants, once taking part in the competition, seemed to be really motivated as indicated by the fact that only few trained less than ten minutes. Unfortunately, we do not have data about the trainees who did not participate and the reasons for their choice.

The cardinal question that remains is whether there is a role for the serious gaming concept in surgical training. The high percentage of trainees with laparoscopic procedural experience that joined the competition suggests that especially this category was motivated to participate. The competition element seems useful to attract experienced trainees for additional skills acquisition. This gaming element can easily be

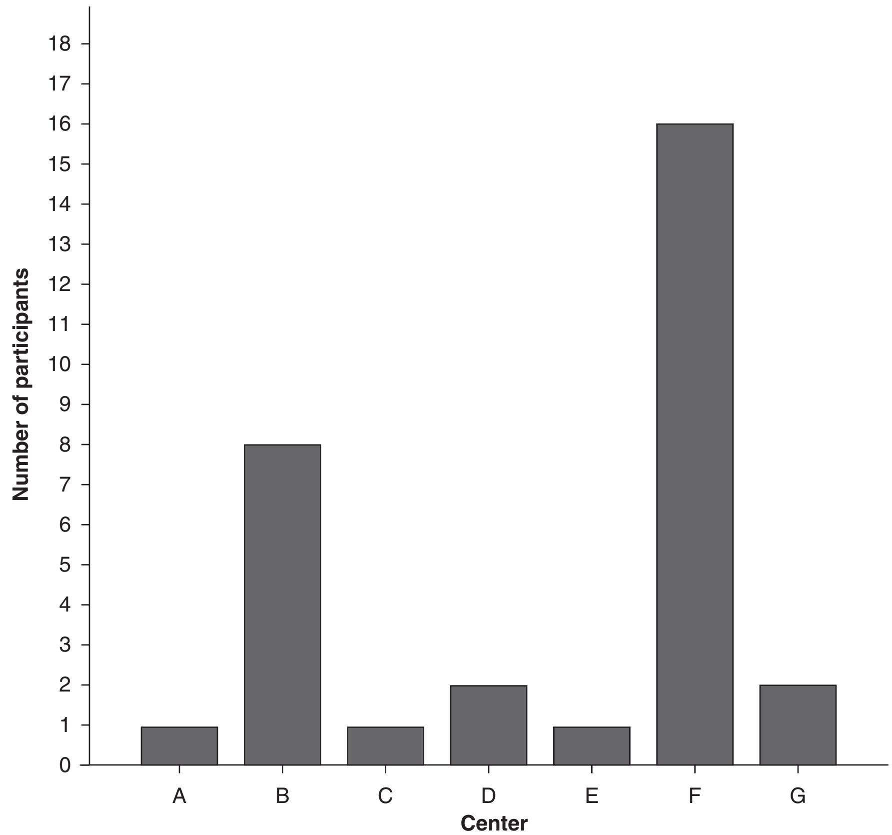

Figure 5. Number of participants and center

added to the existing simulators for laparoscopic motor skills training. The serious gaming concept may be additional to basic laparoscopic skills training in which achieving competence of a basic level, for example until predefined criteria, is mandatory and takes place in the structured setting of a lab. The online data capturing can be helpful to monitor skills acquisition over time and can be used to employ standardized training on a larger scale. The performance of the individual trainee can easily be integrated into a digital portfolio.

For surgery in general, there is a large potential for simulation and serious gaming in training of more complex or cognitive skills such as decision making, diagnosing and learning the steps of common surgical procedures. It is most likely that in the near future serious games for medical trainees will emerge. In other domains, often heavily funded, such as the military and aviation, this new form of training is already successfully being used (7,9). Since improving quality and patient safety in healthcare by efficient, competence-based training has become a high priority, innovative education methods will surface. Cooperation with the gaming industry, adopting their principles, ideas and technology is important. However, the surgical training community should develop the required content, design the educational curriculum and control the validation.

In conclusion, the use of competition elements on the simulator may enhance the motivation of surgical trainees to train voluntarily. Furthermore, data capturing over the Internet could facilitate monitoring of skills progression in surgical trainees and enhance the ongoing validation research of various simulators.

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