Baseline characteristics in laparoscopic simulator performance: The impact of personal computer (PC)–gaming experience and visuospatial ability☆

Ninos Oussi a,b,c, Petra Renman d, Konstantinos Georgiou e, Lars Enochsson a,b,d

a Department of Clinical Science, Intervention and Technology (CLINTEC), Division of Surgery, Karolinska Institutet, Stockholm, Sweden
b The Center for Advanced Medical Simulation and Training (CAMST), Karolinska University Hospital, Stockholm, Sweden
c Centre for Clinical Research Sörmland, Uppsala University, Eskilstuna, Sweden
d Department of Surgical and Perioperative Sciences, Surgery, Umeå University, Umeå, Sweden
e 1st Department of Propaedeutic Surgery, Hippokration General Hospital of Athens, Athens Medical School, National and Kapodistrian University of Athens, Athens, Greece

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ABSTRACT

Background: Learning via simulators is under constant development, and it is important to further optimize simulator training curricula. This study investigates the impact of personal computer–gaming experience, visuospatial skills, and repetitive training on laparoscopic simulator performance and specifically on the constituent parameters of the simulator score.

Methods: Forty-seven medical students completed 3 consecutive Minimally Invasive Surgical Trainer–Virtual Reality simulator trials. Previously, they performed a visuospatial test and completed a questionnaire regarding baseline characteristics and personal computer–gaming experience. Linear regression was used to analyze the relationship between simulator performance and type of personal computer–gaming experience and visuospatial ability.

Results: During the first 2 Minimally Invasive Surgical Trainer–Virtual Reality simulation tasks, there was an association between personal computer–gaming experience and the coordination parameters of the score (eg, EconDiath task 1: P = .0047; EconDiath task 2: P = .0102; EconDiath task 3: P = .0836). The type of game category played seemed to have an impact on the coordination parameters (eg, EconDiath task 1–3 for sport games versus no-sport games: P = .01, P = .0013, and P = .01, respectively). In the first Minimally Invasive Surgical Trainer task, visuospatial ability correlated with Minimally Invasive Surgical Trainer simulator performance but was abolished with repetitive training (overall Minimally Invasive Surgical Trainer score task 1–3: P = .0122, P = .0991, and P = .3506, respectively). Sex-specific differences were noted initially but were abolished with training.

Conclusion: Sport games versus no-sport games demonstrated a significantly better Minimally Invasive Surgical Trainer performance. Furthermore, repetitive laparoscopic simulator training may compensate for a previous lack of personal computer–gaming experience, low visuospatial ability, and sex differences.

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INTRODUCTION

Today, laparoscopic surgery is the criterion standard for many surgical procedures [1]. Laparoscopic surgery has several important differences from the open approach, providing a 2-dimensional view of a 3-dimensional interior, which demands greater hand-eye coordination and gives less tactile feedback. The fulcrum effect, as described by Gallagher et al, is when the laparoscopic instruments’ endpoints move in the opposite direction to the surgeon’s hands because of the pivot point created by the abdominal wall through which the laparoscopic instruments pass, something that surgeons need to consider [2].

Virtual reality (VR) simulators provide an opportunity to training skills required for an entire laparoscopic procedure and to supply feedback to trainees on their performance [3]. Training in VR simulators has been shown to improve laparoscopic skills, and the skills acquired are transferrable to laparoscopic surgery [4–7].

Video Games Experience and Laparoscopic Simulator Performance. Several articles have previously evaluated the similarities between playing video games and performing laparoscopic surgery. Interviews with undergraduate medical students prior to performing a VR simulator task revealed an association between owning a video game device at home and better simulator performance [8]. In a study with fourth-year medical students and first-year residents who trained on the Minimally
Invasive Surgical Trainer–Virtual Reality (MIST-VR, Mentice, Gothenburg, Sweden), those with video gaming experience completed the task faster and had a better score [9]. Although not all results are conclusive, 2 systematic reviews show a positive correlation between video games and simulator performance [10,11]. Still, there is no real consensus about which part of the simulation is enhanced by the video gaming experience [12–16].

**Visuospatial Skills, Sex Differences, and Simulation Performance.** Visuospatial abilities have been found to improve performance in endoscopic simulation [17]. Visuospatial ability also seems to impact performance in more advanced simulation tasks, which has been shown in 2 studies with specialists in endoscopy and gynecology [18,19]. In contrast to the above-mentioned support that visuospatial ability has on laparoscopic performance, one study presents contradictive findings, showing no significant difference between gamers versus nongamers regarding their baseline perceptual as well as visuospatial abilities. They further state that these 2 traits are resistant to any influence of prior experience and video game practice. As for the innate abilities, in regards to video games and its role in training surgical trainees, perhaps not all elements are relevant to surgical performance, stating that “the predictive value of these findings is uncertain” [20].

Additionally, supplementary instructions and recurrent training amplify performance, where prior advantage of visuospatial ability and also any sex-specific differences are being eliminated [21]. Several studies have also shown sex differences in laparoscopic simulator performance [21,22]. However, female students and students with no prior video game experience may “catch up” following additional practice and instructions [21]. Moreover, female residents underestimated their performance scores significantly compared to male residents, who also predicted their scores more accurately. These “surgical ability” estimation differences did not reflect the actual differences in performance [23].

Thus, the value of simulation training to improve surgical skills is well known. However, more research in this field is required regarding which factors influence the simulator performance the most to further optimize the design of training curricula.

Our hypothesis was to elicit whether different categories of video games provide similar results when tested on a laparoscopic simulator.

**Study Aims.** The aim of this study is to evaluate the impact previous personal computer (PC)–gaming experience (the types, or rather, categories of games played) has on the laparoscopic simulator performance, as well as the different parameters that constitute the simulator performance overall score. Furthermore, the study aims to analyze the impact visuospatial ability and sex may have on simulator performance. The data for this study are a further exploration of a recent study performed at the Karolinska Institutet where the performance in a low-cost Laparoscopic Box Trainer (BlackBox), evaluated by automated video analysis, and a MIST-VR was compared [24].

**METHODS**

**Study Participants.** Fifty-seven medical students volunteered to participate in the study during their surgical semester at Karolinska University Hospital. Prior to the simulation training, all participants completed an informed consent following a questionnaire with some baseline questions, for example, age, sex, experience of PC gaming, and categories rather than types of games that they played (role-playing games [RPG], first-person shooter [FPS], sport games [Sport], strategy games [Strategy]). Each participant could provide more than 1 answer to what prior types of video games played. For each participant, the whole procedure was performed in 1 sitting.

**Assessing PC-Gaming Experience.** Self-rated PC-gaming experience, as provided by the questionnaires, was evaluated by the participants on a visual analogue scale [25] where their answers from the questionnaire were subsequently transformed into a numeric value (1–100; given by a mark on a 10-cm drawn line). The median level of “PC gaming experience” was 60%, where “high” score was designated >60%. The visual analogue scale has been used by our group in previous studies [26–28].

**Assessing Visuospatial Ability With the Mental Rotation Test–Version A.** To assess visuospatial ability, prior to the trial, the trainees performed the Mental Rotation Test–version A (MRT-A) [29,30]. The MRT-A is one of the most commonly used tests for measuring spatial ability in which the participants compare 2-dimensional drawings of 3-dimensional geometrical figures [31]. The results are given as percentage. A
percentage score that was >49% was considered high visuospatial ability in this study.

Manipulative Diathermia Medium Tests in MIST-VR. The participants performed 3 consecutive manipulative diathermia medium tests in the previously validated and well-studied MIST-VR [4]. To accomplish the task, the participants first used the left handle to grasp a ball and then touched the ball using the right handle. In doing so, a cube around the ball was created. After withdrawing the right handle and reinserting it, the handle transformed into a diathermia hook. Using a pedal and correct positioning of the diathermia hook, the participants had to characterize a small cube that showed up at different positions on the ball. With the left handle, the ball had to be exactly positioned within the surrounding cube to accomplish the characterization and to make the small cube on the ball disappear (Fig 1). This procedure was repeated with the ball grasped with the right handle. Each trial included 6 procedures: 3 with the right hand alternatively guiding the diathermia hook and 3 with the left hand.

The performance of the trainee, thereafter, was automatically converted into a numeric value as provided by the built-in software of the MIST-VR simulator (the descriptions of each parameter are given by the MIST-VR manufacturer, as seen in Table 1), where a lower score indicates a better performance. For instance, the parameter Econ (Economy of Movement) provides a numeric value for the movement of the instruments inside the box, where large movements lead to higher score, which means worse performance. The total score was calculated based on multiple parameters, described in Table 1. Additionally, in Table 1, the MIST-VR parameters are described and subcategorized into clinically meaningful groups (coordination and precision) and, furthermore, attributed the PC games played into 4 main categories: Sport games, RPG, and Strategy games. This categorization was done to further see whether the types of games, rather than the actual games played, had any effect on the MIST performance.

Statistical Analysis. All statistical analyses were performed with JMP Pro 14.2.0 (SAS Institute Inc, Cary, NC). When comparing performance between the individual MIST trials, the matched-pairs test was used (Fig 2). When doing a regression analysis comparing 2 numerical variables (Tables 2 and 3), linear fit with analysis of variance was used. The Student t test was used when comparing the effect of the different PC-gaming categories on the outcome of the coordination variables (Table 4). A P value < .05 was considered statistically significant. A P value .05–.10 was considered a trend.

Ethical Considerations. The study was approved by the Regional Research Ethics Committee at Karolinska Institutet, Stockholm, Sweden (Dnr: 2013/2284-31/4). All subjects had to complete an informed consent prior to participation.

RESULTS

Baseline Demographics. Nine participants were excluded for not completing all 3 simulations in the MIST-VR. The reasons for their dropouts where stress due to future examinations (n = 3), exceeding the maximum time allowed to perform the task (n = 2), and loss of interest (n = 4). When presenting the data graphically, an outlier in the PC-gaming experience group was identified and excluded. Therefore, the final analyses were performed using 47 participants with mean age of 26.6 years ± 4.7 SD. There was a fairly equal distribution between men and women (23 men, 24 women) (Table 5). Regarding PC-gaming category, 48.9% played FPS (Table 5).

PC-Gaming Experience and MIST Score Parameters

In a regression analysis, we found no correlation between PC-gaming experience and the overall MIST-VR score (Table 2). However, there seemed to be a significant association between the PC-gaming experience and some of the variables of the score associated with coordination in both the first and second MIST trials. However, this association was abolished in the third MIST trial (Table 2). We found no convincing sex-specific differences in this pattern.

Regarding the variables constituting coordination (EconDiath, TmDiathAir, TipInSphOn, and TmDiathSph; see Table 1), we found that those that played Sport games performed significantly better in all MIST trials (Table 4). Almost similar results were seen for those who played FPS games, although, in contrast to those who played RPG, and even less for those playing Strategy games (Table 4).

Visuospatial Ability and MIST Score Parameters

In a regression analysis comparing the overall visuospatial ability and the MIST score, we noted an association between all of the MIST score variables and the visuospatial ability. This association diminished gradually in MIST task 2 and was completely abolished in MIST task 3 (Table 3).

Visuospatial Ability and Sex Differences

We found some interesting sex-specific differences in that, in the precision parameters of the MIST score as well as the coordination parameters, there was a significant association between the visuospatial ability and the scores in women during the first MIST trial. In men, we found no associations regarding these parameters. However, in men, there was an association between visuospatial ability and time in the first MIST trial which gradually disappeared with additional trials (Table 3).

Table 1

| Category         | MIST-parameter* | Description                                                                 |
|------------------|-----------------|-----------------------------------------------------------------------------|
| Overall MIST score | Score           | The final score of each test                                                |
| Time             | Time L/R        | Total time of the test                                                     |
| DiaTipRem        | DiaTipRem L/R   | Number of times the error of removing the diathermy tool tip from the subtarget to be burned occurred. |
| Econ             | Econ L/R        | Economy of movement for left and right hand, respectively. The ratio of actual tool movements during the task segments for each hand to the optimal calculated movement of the tools necessary to complete the task. Therefore, the best results are the ones that approach the value of 1. The ratio of time that diathermy pedal was pressed during the task segments for each hand to the optimal - shortest time necessary to burn off the subtargets. The best value of this parameter should approach 1. The times pedal was pressed while the diathermy tool did not touch the main target object or any of the subtargets. The times pedal was pressed while the diathermy tool did not touch the main target object or any of the subtargets. The times pedal was pressed while the diathermy tool did not touch the main target object or any of the subtargets. The time of contact between diathermy tool and main target while the pedal was pressed. |
| Coordination     | TmDiathAir      | Number of times the error of making contact between diathermy tool tip and the main target while pressing the pedal was committed for each hand. |
| TmDiathAir       | TmDiathAir L/R  |                                                                             |
| TipInSphOn       | TipInSphOn L/R  |                                                                             |
| TmDiathSph       | TmDiathSph L/R  |                                                                             |

* Abbreviations as given by the MIST-VR simulator.
Simulator Performance

Simulator performance improved significantly between the first 2 MIST trials (Fig 2). The absolute scores of the third MIST trial were better than for the second MIST trial but not significantly so. Likewise, the absolute MIST trial scores for men were better when compared to women at each of the MIST trials, but no significant differences were registered (Fig 2).

DISCUSSION

In the literature, there are conflicting opinions on how PC-gaming experience and visuospatial ability affect laparoscopic performance. The studies in this field are heterogeneous when it comes to study design, definitions, type of simulator used, and the analysis of different parts of the simulation, thus making comparisons difficult.

Therefore, in this study, we attempted to evaluate the impact of previous PC-gaming experience and of visuospatial ability into (1) the different parameters constituting the overall laparoscopic simulator performance, (2) the type of games played, and (3) the impact of sex on simulator performance.

PC-Gaming Experience and Outcome on MIST Trial Performance. Although there was no association between PC-gaming experience and the final simulator overall score in the 3 MIST trials, we found an association between PC-gaming experience and the coordination parameters of the first 2 MIST-VR simulator tasks (Table 2). This is, to some extent, in line with the results of Kennedy et al who have shown a positive impact of previous video gaming, with the video gaming group being faster and having a shorter instrument path length, whereas no difference was found for instrument smoothness [20]. Furthermore, in a study by Grantcharov et al examining surgical residents with limited laparoscopic experience regarding sex, hand dominance, and PC-gaming experience and its impact on MIST-VR performance, they found that PC gamers made significantly less errors than the control group, whereas differences in time and "unnecessary movements" were not significant. They further found that right-handed surgical residents performed significantly better than the left-handed residents [12]. In contrast to our study, Van Dongen et al found better total scores, efficiency, and speed among adults with video gaming experience when tested in the LapSim VR simulator [16]. Accordingly, another study showed that video gaming experience results in both reduced time and less errors. That study also suggested that the number of hours spent playing video games resulted in better virtual reality laparoscopy skills outcomes [14]. Furthermore, in a review by Jalink et al, although positive correlations between video game experience and laparoscopic simulator skills were shown, other factors may affect the simulator performance, which should be taken into account [10]. However, a recent study contradicts the finding regarding transfer of skills, stating that

![Fig 2. The final overall scores, as well as divided into sex, of the 3 consecutive MIST-VR trials. ***P < .001 between the first and second trial in men. **P < .01 between the first and second trial in women. Matched-pairs test used.](image-url)

| PC-gaming experience | MIST task 1 | MIST task 2 | MIST task 3 |
|----------------------|------------|------------|------------|
| Overall MIST score   | 0.41       | 0.47       | 0.46       |
| Time                 | 0.10       | 0.19       | 0.10       |
| DiaTipRem            | −0.03      | 0.69       | −0.02      |
| Econ                 | 0.01       | 0.92       | 0.01       |
| EconDiath            | 0.18       | 0.04       | 0.19       |
| TmDiaArt             | 0.37       | 0.09       | 0.12       |
| TipInSphOn           | 0.06       | 0.56       | 0.04       |
| TmDiaSphSph          | 0.17       | 0.01       | 0.14       |

Statistically significant P values highlighted in underline; trends (P < .10) in italic.
Table 3
Regression analysis between visuospatial ability and the specific parameters of the MIST simulator

| Overall visuospatial ability | MIST task 1 | MIST task 2 | MIST task 3 |
|-----------------------------|-------------|-------------|-------------|
|                             | Regression coefficient | P | R² | Regression coefficient | P | R² | Regression coefficient | P | R² |
| Overall MIST score          | −3.10       | .0172       | 0.13 | −1.68       | .0991       | 0.06 | −0.98       | .3506       | 0.02 |
| Time                        | −0.42       | .0164       | 0.12 | −0.27       | .0551       | 0.08 | −0.15       | .2620       | 0.03 |
| DiaTipRem                   | −0.41       | .0946       | 0.17 | −0.17       | .0834       | 0.07 | −0.07       | .5033       | 0.01 |
| Econ                        | −0.04       | .0354       | 0.09 | −0.02       | .0824       | 0.07 | −0.02       | .3444       | 0.02 |
| EconDiath                   | −0.31       | .0322       | 0.10 | −0.09       | .4905       | 0.01 | −0.02       | .8102       | 0.00 |
| Coordination                |             |             |      |             |             |      |             |             |      |
| TmDiaThAir                  | −0.67       | .0888       | 0.09 | −0.18       | .5024       | 0.01 | −0.06       | .7073       | 0.00 |
| TpInSphOn                   | −0.11       | .0274       | 0.10 | −0.02       | .5742       | 0.01 | 0.01        | .6327       | 0.00 |
| TmDiaThSph                  | −0.27       | .0220       | 0.10 | −0.08       | .5132       | 0.01 | 0.01        | .8978       | 0.00 |
| Visuospatial ability: women |             |             |      |             |             |      |             |             |      |
| MIST task 1                 | Regression coefficient | P | R² | Regression coefficient | P | R² | Regression coefficient | P | R² |
| Overall MIST score          | −3.44       | .0819       | 0.13 | −1.43       | .3975       | 0.03 | −0.91       | .5988       | 0.01 |
| Time                        | −0.27       | .3010       | 0.05 | −0.17       | .4291       | 0.03 | −0.10       | .6188       | 0.01 |
| DiaTipRem                   | −0.63       | .0094       | 0.27 | −0.21       | .1223       | 0.07 | −0.06       | .7540       | 0.00 |
| Econ                        | −0.04       | .2206       | 0.07 | −0.01       | .6576       | 0.01 | −0.02       | .5547       | 0.02 |
| Coordination                |             |             |      |             |             |      |             |             |      |
| TmDiaThAir                  | −0.44       | .0437       | 0.17 | −0.04       | .8541       | 0.00 | 0.06        | .6308       | 0.01 |
| TpInSphOn                   | −0.18       | .0126       | 0.20 | −0.01       | .9247       | 0.00 | 0.06        | .2693       | 0.06 |
| TmDiaThSph                  | −0.40       | .0337       | 0.16 | −0.04       | .8431       | 0.00 | 0.06        | .6245       | 0.01 |
| Visuospatial ability: men   |             |             |      |             |             |      |             |             |      |
| MIST task 1                 | Regression coefficient | P | R² | Regression coefficient | P | R² | Regression coefficient | P | R² |
| Overall MIST-score          | −2.15       | .1624       | 0.09 | −1.75       | .1297       | 0.11 | −0.83       | .4904       | 0.02 |
| Time                        | −0.56       | .0237       | 0.22 | −0.37       | .0687       | 0.15 | −0.20       | .2925       | 0.09 |
| DiaTipRem                   | −0.06       | .5743       | 0.01 | −0.12       | .3003       | 0.05 | −0.02       | .8327       | 0.00 |
| Econ                        | −0.02       | .1283       | 0.11 | −0.04       | .0273       | 0.21 | −0.02       | .5468       | 0.02 |
| Coordination                |             |             |      |             |             |      |             |             |      |
| TmDiaThAir                  | −0.04       | .8372       | 0.00 | −0.07       | .6521       | 0.01 | −0.10       | .1764       | 0.09 |
| TpInSphOn                   | 0.03        | .4329       | 0.03 | −0.01       | .8267       | 0.00 | −0.03       | .3994       | 0.03 |
| TmDiaThSph                  | 0.03        | .7572       | 0.02 | −0.02       | .8160       | 0.00 | −0.02       | .6094       | 0.01 |

Statistically significant P values highlighted in underline; trends (P < .10) in italic.

perhaps motivation to play video game (in this case, Underground) rather than actual skills would explain the results seen in performance [33]. Furthermore, in a recent review by Glassman et al., the amount of evidence backing up the effects of video games on surgical simulation performance was presented as limited, and furthermore, there was no evidence at all regarding its effects on laparoscopic surgery performance [11]. Thus, the above-mentioned articles present somewhat a different picture of the relationship between video gaming experience and simulator performance.

Interestingly, we note a learning effect in the final simulation attempt. The value of prior PC-gaming experience was reduced to a non-significant level (Table 2). A conclusion from this finding is that even though PC-gaming experience has an impact on the coordination performance of novices in the initial laparoscopic simulator session, a more important factor seems to be the repetitive practice of the laparoscopic procedure. We did not find any apparent sex-specific differences regarding PC-gaming experience and outcome of the MIST trials.

PC-Gaming Categories and Outcome on MIST-Trial Coordination Parameters. The type of categories of PC games that the participants played seemed to have an impact on the coordination parameters of the MIST trials (Table 4). Students who considered themselves to be in the sport-gaming category had significantly better values in all of the coordination parameters of the 3 MIST trials. In the FPS category, there was a similar pattern that, however, seemed to disappear somewhat in the last MIST trial. In the RPG and Strategy categories, there were, with the exception of 1 parameter in the first MIST trial, no differences (Table 4). These results are in line with the study by Schlickum et al., where 30 surgical novices were randomized to 5 weeks of systematic video game training in either an FPS game (Half Life) or a video game with predominantly cognitive demands (Chessmaster). The students who had trained in FPS performed better in both the MIST-VR as well as the endoscopic simulator GI Mentor II [34]. In our study, the students did a self-assessment of which category/categories they belonged to, and thus, we do not have any data as to exactly what games they played and with which frequency.

Visuospatial Ability and Outcome on MIST Trial Performance. This study reveals a significant association between visuospatial ability, as measured by the MRT-A, and simulator performance in the MIST-VR during the first of 3 consecutive exercises that gradually subsided during the following 2 exercises. This might indicate a training effect that compensates for variation in the visuospatial ability across study participants (Table 3). However, in a study by Kennedy et al, no impact of visuospatial score was found [20], whereas other studies have shown a clear correlation between visuospatial abilities and endolaparoscopic simulation performance [17,18].
trials 2 and 3 (in women, there was also a trend toward an improvement between
both sexes showed a similar pattern with an improvement over time,
the effect of different gaming categories on the coordination parameters of the MIST score
Table 4

| Student t test | RPC gaming | No RPC gaming |
|---------------|------------|---------------|
|               | Mean SEM   | Mean SEM      | P     |
| EconDiath     | 7.50 1.85  | 13.28 3.39    | .1424 |
| TmDiathAir    | 15.99 4.57 | 26.74 7.47    | .2264 |
| TplnSphOn     | 3.86 0.88  | 6.02 1.07     | .1261 |
| MIST task 1   | 3.50 1.05  | 10.09 2.92    | .0411 |
| EconDiath     | 6.06 1.84  | 10.82 2.75    | .1574 |
| TmDiathAir    | 12.31 4.16 | 21.22 5.77    | .2167 |
| TplnSphOn     | 2.81 0.63  | 4.63 0.95     | .1162 |
| MIST task 2   | 3.77 1.03  | 7.24 1.64     | .0806 |
| EconDiath     | 6.89 2.38  | 15.28 3.57    | .0568 |
| TmDiathAir    | 2.53 0.66  | 3.34 0.65     | .3852 |
| MIST task 3   | 1.44 0.77  | 3.40 1.60     | .2749 |

Table 5

| Visuospatial score | High | Low |
|--------------------|------|-----|
| PC-gaming experience | 25   | 40.4 |
| Sport gaming No-sport gaming |
| Mean SEM | Mean SEM | P |
| EconDiath | 6.80 1.54 | 15.16 3.97 | .0592 |
| TmDiathAir | 13.91 3.75 | 30.98 8.77 | .0833 |
| TplnSphOn | 3.89 0.67 | 6.44 1.29 | .0881 |
| MIST task 1 | 3.47 0.94 | 11.50 3.45 | .0331 |
| EconDiath | 5.10 1.32 | 12.73 3.26 | .0377 |
| TmDiathAir | 10.05 3.00 | 25.25 6.86 | .0508 |
| TplnSphOn | 2.65 0.43 | 5.17 1.15 | .0493 |
| MIST task 2 | 2.26 0.99 | 9.96 3.33 | .0357 |
| EconDiath | 3.75 0.73 | 7.98 1.98 | .0547 |
| TmDiathAir | 7.31 1.96 | 16.64 4.23 | .0540 |
| TplnSphOn | 2.54 0.48 | 3.50 0.81 | .3158 |
| MIST task 3 | 0.94 0.40 | 4.20 1.94 | .1039 |

The final scores of women improved between all 3 exercises, in contrast to men where the third trial only showed minor improvement, indicating an improved learning effect for women with repetitive simulator training. This suggests that there is value in identifying this group (women with low PC-gaming experience) to provide them with more opportunities for laparoscopic simulator training. When preparing a training curriculum or developing simulators, it is also important to take these differences into consideration and perhaps focus more on coordination and precision training for the group with women, something that does not necessarily involve simulator training in the initial phase.

Limitations of the Study. A rather small study group and a 16% dropout (9 of 57) of the original study participants are limiting factors in this study. Furthermore, video games differ in their causative outcome for simulator performance [34]. A better outlined prequestionaire could help to distinguish between the gamer’s choice of games. If this study was to be repeated, it would be interesting to also include an objective evaluation of PC-gaming skills and experience. One way to further evaluate the participants’ gaming performance is by preparing more thoroughly designed questionnaires; gathering additional information, for instance, by focusing on what types of video games played, how much time spent playing, and perhaps also their motivation, satisfaction, and preferable types of games played; and comparing it with the participants’ actual simulator performance. Furthermore, the use of the validated tests of the MIST-VR is arguable because newer and more sophisticated VR simulators are available. However, the MIST-VR has been widely used, and according to Gallagher and O’Sullivan, it does not attempt to simulate the tissue; rather, it focuses on the computer processing capacity and training the psychomotor skills in eye-hand coordination that are required in laparoscopic cholecystectomy [38]. Furthermore, in a review of a total of 24 studies contrasting high- and low-fidelity simulators, almost all studies presented no significant advantages of high- over low-fidelity simulators [39].

Conclusion

In conclusion, both PC-gaming experience and visuospatial abilities had a significant impact on various parameters in the laparoscopic MIST simulator. However, the differences of these factors were no longer apparent by the third simulation, a finding which indicates an important training effect that compensates for most of the differences in baseline skills. Nonetheless, sport games versus no-sport games showed a significantly better MIST performance in all 3 MIST tasks. Thus, the groups with low PC-gaming experience, those with low visuospatial score, and women will benefit not only from further repetitive simulator training but also (according to our study) by focusing more on training in coordination and precision. In conclusion, repetitive laparoscopic simulator training clearly enhances simulator performance.

Although the absolute MIST trial scores in men were better than in women, they did not differ significantly (Fig 2). Men showed a steeper learning curve between MIST trials 1 and 2 as compared to women. Both sexes showed a similar pattern with an improvement over time, although it was only significant between trials 1 and 2 (Fig 2). However, in women, there was also a trend toward an improvement between trials 2 and 3 (P = .0724); no such trend was found in men.
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• Ann Kjellin, MD, PhD, and Lars Henningson, MD, PhD, Associate Professor at the Center for Advanced Medical Simulation and Training, Karolinska University Hospital, Stockholm, Sweden

Availability of data and material

Because of Swedish regulations regarding privacy and integrity and also because of concerns regarding the possibility of identifying individual participants using their demographic information and survey answers, no datasets generated and/or analyzed during this study are publicly available. All datasets are unidentified and stored in the repository of Karolinska Institutet (https://owncloud.ki.se/), only available from the corresponding author on reasonable request, and will be destroyed after 10 years.

Authorship contributions

NO and LE conceived of the presented idea. NO, LE and KG designed the study. NO, PR and LE collected the data. NO, LE and KG analyzed the data. NO, PR and LE wrote the article. KG reviewed the article. All the authors discussed the results and contributed to the final manuscript.

Conflicts of Interest

All the authors have no conflict of interest to declare.

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References

[1] Keus F, de Jong J, Gosszen HG, et al. Laparoscopic versus open cholecystectomy for patients with symptomatic cholecystolithiasis Cochrane Database Syst Rev Epub ahead of print, 2006. https://doi.org/10.1002/14651858.CD006231.
[2] Gallagher AG, McClure N, Mcguigan J, et al. Virtual reality training in laparoscopic surgery: a preliminary assessment of minimally invasive surgical trainer virtual reality (MIST VR). Endoscopy. 1999;31:310–3.
[3] van Empel P, van der Veer WM, van Rijssen LB, et al. Mapping the maze of minimally invasive surgery simulators. J Laparoendosc Adv Surg Tech A. 2012;22:51–60.
[4] Seymour NE, Gallagher AG, Roman SA, et al. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. Ann Surg. 2002;236:458–63 [discussion 463-464].
[5] Grantcharov TP, Kristansen VB, Bendix J, et al. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. Br J Surg. 2004;91:146-50.
[6] Ahlberg C, Enochsson L, Gallagher AG, et al. Proficiency-based virtual reality training significantly reduces the error rate for residents during their first 10 laparoscopic cholecystectomies. Am J Surg. 2007;193:797–804.
[7] Larsen CR, Soerensen JL, Grantcharov TP, et al. Effect of virtual reality training on laparoscopic surgery: randomised controlled trial. BMJ. 2009;338:b1802.
[8] Paschold M, Schröder M, Kauff DW, et al. Virtual reality laparoscopy: which potential trainees starts with a higher proficiency level? Int J Comput Assist Radiol Surg. 2011; 6:653–62.
[9] Shane MD, Pettitt BJ, Morgenthaler CB, et al. Should surgical novices trade their retractor for a joystick? Videogame experience decreases the time needed to acquire surgical skills. Surg Endosc. 2008;22:1294–7.
[10] Jalink MB, Gori J, Heineman F, et al. The effects of video games on laparoscopic simulator skills. Am J Surg. 2014;208:151–6.
[11] Classman D, Yasemidou M, Isshi H, et al. Effect of playing video games on laparoscopic skills performance: a systematic review. J Endourol. 2016;30:146–52.
[12] Grantcharov TP, Bardram L, Funch-Jensen P, et al. Impact of hand dominance, gender, and experience with computer games on performance in virtual reality laparoscopy. Surg Endosc. 2003; 17:1082–5.
[13] Rosenberg BH, Landsittel D, Averch TD. Can video games be used to predict or improve laparoscopic skills? J Endourol. 2005;19:372–6.
[14] Rosser JK, Lynch PJ, Cuddihy L, et al. The impact of video games on training surgeons in the 21st century. Arch Surg Chir Ils 1960 2007; 142: 181–186. discussion 186.
[15] Van Hove C, Perry KA, Spight DH, et al. Predictors of technical skill acquisition among resident trainees in a laparoscopic skills education program. World J Surg. 2008;32: 1917–21.
[16] van Dongen KW, Verleisdonk E-JMM, Schijven MP, et al. Will the Playstater generation become better endoscopic surgeons? Surg Endosc. 2011;25:2275–80.
[17] Enochsson L, Isaksson B, Tour R, et al. Visuospatial skills and computer game experience influence the performance of virtual endoscopy. J Gastrointest Surg Off J Soc Surg Alamn Tract. 2004;8:876–82 (discussion 882).
[18] Ahlberg L, Hedman L, Murdes D, et al. Visuospatial ability correlates with performance in simulated gynocoalogical laparoscopy. Eur J Obstet Gynecol Reprod Biol. 2011;157:73–7.
[19] Enochsson L, Westman B, Ritter EM, et al. Objective assessment of visuospatial and psychomotor ability and flow of residents and senior endoscopists in simulated gas- troscopy. Surg Endosc. 2006;20:895–9.
[20] Kennedy AM, Boyle EM, Traynor O, et al. Video gaming enhances psychomotor skills but not visuospatial and perceptual abilities in surgical trainees. J Surg Educ. 2011; 68:414–20.
[21] Abbas P, Holder-Haynes J, Taylor DJ, et al. More than a camera holder: teaching surgical skills to medical students. J Surg Res. 2015;195:385–9.
[22] Lin D, Pena G, Field J, et al. What are the demographic predictors in laparoscopic sim- ulator performance? ANZ J Surg. 2016;86:983–9.
[23] Flyckt RL, White EE, Goodman LR. The use of laparoscopy simulation to explore gender differences in resident surgical confidence. Obstet Gynecol Int, et al. Epub ahead of print. IOSI. 2017. https://doi.org/10.1155/2017/1945801.
[24] Oussi N, Loukas C, Kjellin A, et al. Video analysis in basic skills training: a way to ex- pand the value and use of BlackBox training? Surg Endosc. 2018;32:87–95.
[25] Bond A, Lader M. The use of analogue scales in rating subjective feelings. Psychol Psychother. 1974;47:211–8.
[26] Ahlberg L, Hedman L, Nilssen H, et al. Simulator training and non-technical factors im- prove laparoscopic performance among OB/GYN trainees. Acta Obset Gynecol Scand. 2013;92:1194–201.
[27] Ahlberg L, Weurlander M, Hedman L, et al. Individualized feedback during simulated laparoscopic training: a mixed methods study. Int J Med Educ. 2015;6:93–100.
[28] Oussi N, Enochsson L, Henningson L, et al. Trainee performance after laparoscopic simulation training using a Blackbox versus Lapmaster LT. J Surg Res. 2020;250:1–11.
[29] Peters M, Laeng B, Latham K, et al. A redrawn Vandenberg and Kuse mental rotations test: different versions and factors that affect performance. Brain Cogn. 1995;28:39–58.
[30] Schlickum M, Hedman L, Enochsson L, et al. Surgical simulation tasks challenge visual working memory and visual-spatial ability differently. World J Surg. 2011;35:710–5.
[31] Cassire AF, Vigneau F, Bors DA. What does the mental rotation test measure? An analysis of item difficulty and item characteristics. Open Psychol. 2009;2:94–102.
[32] Ijgosse WM, van Goor H, Luursema J-M, et al. Saved robots improves laparoscopic perfor- mance: a mixed methods study. Int J Med Educ. 2015;6:93.
[33] Schlickum MK, Hedman L, Enochsson L, et al. Systematic video game training in sur- gical novices improves performance in virtual reality endoscopic surgical simulators: a prospective randomized study. World J Surg. 2009;33:2683–73.
[34] Thorsen CM, Kelly JP, Forse RA, et al. Can we continue to ignore gender differences in performance on simulation training? J Laparoendosc Adv Surg Tech A. 2011;21:329–33.
[35] Ali A, Subhi V, Ringsted C, et al. Gender differences in the acquisition of surgical skills: a systematic review. Surg Endosc. 2013;27:3065–73.
[36] Gallagher AG, O’Sullivan GC. Principles and Practice. Springer Science & Business Media: Fundamentals of surgical simulation; 2011.
[37] Norman G, Dore K, Grierson L. The minimal relationship between simulation fidelity and transfer of learning. Med Educ. 2012;46:636–47.