Randomized comparison of the portable laparoscopic trainer to a standardized trainer in surgically naïve subjects

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Dedication

To my fellow classmates in the Class of 2013.

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Abstract

PURPOSE: To evaluate the effectiveness of the portable laparoscopic trainer in improving skills in novice subjects.

MATERIALS AND METHODS: Twenty-nine medical students with no prior surgical experience were recruited and given a pretest of three tasks on a standardized laparoscopic trainer. Subjects were evaluated objectively and subjectively. Fifteen subjects were randomized to receive a portable laparoscopic trainer and 14 subjects were assigned to the standardized laparoscopic trainers at our facility. The portable trainer group was advised but not required to complete at least 3 hours of training. The group at the facility had a proctored 1-hour session each week for 3 weeks. Each subject was then retested and evaluated with the same pretest tasks. Objective and subjective improvements between the groups were compared.

HYPOTHESIS: Both the portable and standardized trainer groups were expected to improve comparably based on objective and subjective measures. The portable group had a theoretical objective advantage due to unlimited practice time and the standardized group had the advantage of proctored training sessions, thought to increase subjective performance.

RESULTS: Baseline demographics and pretest scores were similar between both groups. All students in the facility group completed the three 1-hour proctored sessions. The portable trainer group reported an average 204 minutes of practice. Objectively, the facility group did better on the post-test in overall time, and in two exercises. Subjectively, the facility group had a significant improvement compared with the portable trainer group (4.6 versus 2.4 point average increase, P=0.03).

CONCLUSIONS: Both groups showed objective and subjective improvement after a 3-week period of training. The portable trainer group did report longer average practice time, but this made no significant difference in subjective or objective improvement. The portable laparoscopic trainer is an effective method for improvement of basic laparoscopic skills, but inferior compared to proctored sessions on a standard trainer

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Introduction

Background

Minimally invasive surgery has become a mainstay in the surgical management of disease. In many cases, minimally invasive surgery is even considered the standard of care. Because of this, learning laparoscopic skills has become an integral part of surgical residency training. Postgraduate surgeons have even gone through "mini-fellowships" to obtain these vital skills[1]. Because of the significant learning curve, live patient surgery is not the ideal setting in which to learn or refine one's techniques.

Various simulators and standard trainers have been created to help physicians in this regard. These include models as simple as box trainers (low fidelity) to complex virtual reality simulators (high fidelity)[2]. A prospective randomized study from Matsumoto et al. showed that low fidelity models are just as effective as high fidelity models in improving laparoscopic skills and do so at a lower cost[3].

Several different portable webcam and box trainers have been tested and validated in the past[4-6]. Webcam trainers are transportable and can be used anywhere in contrast to the standard laparoscopic trainers and virtual reality trainers. In addition, they are relatively inexpensive which makes it feasible for subjects to have their own trainer to use at their leisure. This makes it an ideal model for novices in laparoscopy who may need extra practice in order to master basic tasks.

We compared the effectiveness of improving laparoscopic skills between the TASKit (Ethicon Endo-surgery Inc.) portable webcam trainer and the standard video laparoscopic trainer (Karl Storz Endoscopy) in surgically naïve subjects.

Significance

This study is the first to explore the efficacy of the TASKit Trainer in surgically naïve subjects. It serves as the foundation for further study with the TASKit Trainer as well as other webcam-based trainers. By using subjects with no prior laparoscopic surgical experience, a baseline is established. Our study sought to compare the effectiveness of the at-home trainer versus traditional techniques. With this established, further studies are able to explore additional avenues such as ideal training schedule, subjects with surgical experience, new training activities and so on.

Our study also seeks to demonstrate a cost-effective and timely method to train surgical residents. With 80-hour workweek restrictions and increasing clinical responsibility, surgical simulation is often omitted in surgical training. With an at-home trainer, the surgical resident can gain elementary laparoscopic skills in a risk-free environment at his or her leisure. Our study seeks to prove the TASKit Trainer as an effective laparoscopic surgical training device in achieving this goal.

Aims/Goals/Hypothesis

The primary aim of this study was to evaluate the effectiveness of an at-home trainer versus a traditional facility-based training program. To assess this, subjective (proctor scoring) and objective (timing) endpoints were established based on instrument smoothness, efficiency of motion and instrument integration. The ideal subject population was one with no prior laparoscopic experience, but with sufficient interest to promote routine practice. For this reason, first and second year medical students were chosen to participate. The goal of the study was to provide a realistic application of the at-home trainer in order to identify not only its efficacy, but also the end-user's experience.

Ancillary endpoints were assessed through a survey given at the conclusion of the study. These endpoints included student interest in surgical careers prior to and after participation, factors limiting practice time, and prior video game or musical instrument experience.

We hypothesized that both groups would improve from pretest to posttest. It was theorized that the at-home trainer would have an advantage due to unlimited practice time and would therefore show greater improvement, at least objectively. Conversely, the standardized facility-trained group had the advantage of proctored instruction, which was predicted to demonstrate greater subjective improvement than the at-home group.

Environment

Testing and proctored training sessions took place at Mayo Clinic Hospital in Scottsdale, Arizona through the Department of Urology in a dedicated laparoscopic simulation lab. The lab was equipped with five standard video laparoscopic training modules as well as one TASKit trainer. The facility-trained group was divided into smaller groups to allow adequate time on the modules. Laparoscopic instruments were provided for use with the modules. Urology residents, with attending physician supervision, provided focused instruction for the facility-trained group. Exercises included those in the pre-test as well as advanced techniques such as laparoscopic knot tying. The laboratory was reserved for training and testing sessions and provided the ideal setting in which to assess performance and standardize testing.

At-home training sessions required the use of a home computer to which the webcam-based TASKit trainer was connected. Each trainer was equipped with a webcam, operative box, laparoscopic instruments as well as objects necessary for exercises. Practice environment variability was not assessed nor standardized. Most subjects, however, used their trainer within their home. Instruction was self-guided and included the pre-test activities as well as tasks included with the trainer. Practice environments were bound to be diverse, but accurately represent real world application of such a trainer.

Innovation

Many training modalities exist to aid residents in gaining essential laparoscopic skills. This training traditionally takes place in the operating theater on live patients. While this is still a key venue for learning advanced skills, it is not ideal for developing basic familiarity with instrument mechanics. Simulation trainers allow trainees to develop these primary skills in a risk-free environment.

Several studies have shown the benefit of surgical simulation on improving operative skill and efficiency. However, surgical simulation labs may have limited availability. Resident physicians are also bound by work hour restrictions and clinical duties may not allow for dedicated time to practice in a simulation lab. For these reasons, at-home training devices are an alternative method of simulation training and do so at lower cost.

This study represents the first of its kind. No prior study has examined the efficacy of the TASKit at-home trainer on surgically-naïve subjects. With proof of efficacy in improving surgical skill, such at-home simulation devices may become commonplace in surgical residency training programs nationwide.

Materials and Methods

After IRB approval and informed consent was obtained, we recruited twenty-nine first and second year medical students to participate in the study. They were given a brief introduction of the use of the laparoscopic instruments and instructions on how to perform three tasks on a standardized laparoscopic trainer.

The first task was a peg transfer exercise where subjects placed four pegs onto a designated diagonal line of a pegboard. The second task consisted of a rope passing exercise. Students used both graspers to transfer a 140 cm string from one end to the other with designated colored marks as grasping points. This exercise was designed to simulate running the bowel during abdominal laparoscopic surgery. The final task involved transferring a fuzzy ball under a plastic hoop between two instruments (Figure 1). Subjects were evaluated objectively (timed) and subjectively using a 1-5 point scale evaluating four different parameters (Table 1). Once the pre-test was completed, the subjects were asked to complete a survey regarding previous surgical experience, medical specialty interests, and the perceived difficulty of the tasks and use of laparoscopic instruments.

Following the pre-test and survey, the medical students were randomized into two groups. Fifteen subjects were randomized into the group who received a portable laparoscopic (TASKit) trainer to use at home. The other remaining fourteen subjects were assigned to use the standardized laparoscopic trainers at the facility. The portable trainer group subjects were encouraged to practice at home as their schedules allowed with a suggested 3 hours of total practice time. They were given the equipment and instructions to practice the pre-test tasks, as well as ten additional practice exercises included with the kit. The facility group attended a proctored 1-hour session each week for 3 weeks (Figure 2). The facility group also had access to practice on the portable laparoscopic trainer during their proctored sessions (Figure 3). Proctors included attending physicians and residents from the Department of Urology at Mayo Clinic. Proctors participated on a volunteer basis and all subjects were compensated with $100 gift cards.

Table 1. Subjective Scoring Sheet

	Scale				
Performance	1	2	3	4	5
Motion	Unnecessary moves		Efficient, but unnecessary moves present		Efficient and excellent movement
Instrument Handling	Awkward, inappropriate movement		Competent but awkward		Fluid without awkward movement
Use of Two Hands	Only used 1 hand		Used 2 hands but inappropriately		Excellent use of 2 hands
Overall Performance	Unable to perform tasks independently		Competent, minimal assistance		Independent, superior, confident

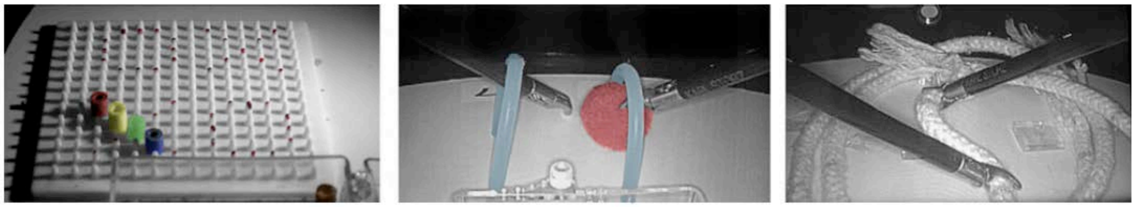

Figure 1. Pre-test and post-test tasks (peg transfer exercise, fuzzy ball exercise, and running the bowel exercise).

Figure 2. Students practicing on standard laparoscopic trainers.

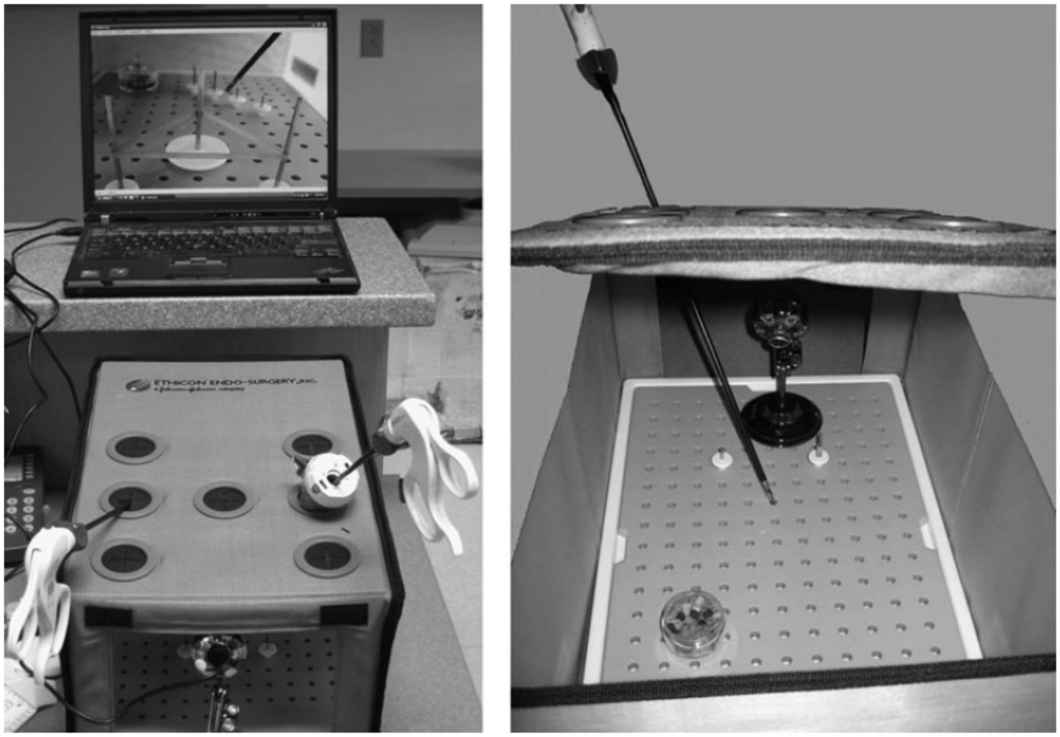

Figure 3. Portable laparoscopic trainer (TASKit).

At the end of three weeks, each subject was then retested and evaluated with the same three tasks. Objective and subjective improvement between the groups were compared. Hours of training and barriers to training were also compared. Statistical analysis was performed using Fisher's exact test for nominal variables and Wilcoxon rank-sum tests for continuous variables.

Results

Fourteen subjects were randomized into the standard laparoscopic trainer group (Group A) and 15 subjects in the portable laparoscopic trainer group (Group B). Each group had equal proportions of males and females (Table 2). The average age of the portable trainer group was 26.4 years and the facility group, 24.2 years (P=0.03). Only one student had prior laparoscopic experience and was randomized into the facility group. This subject's experience was limited to brief camera operation in a limited number of cases. Performance by this subject was not significantly better than that of other subjects and not believed to affect the overall results. There were no other statistically significant differences in baseline demographics between the two groups (Table 2). There were no statistically significant differences in the pretest scoring between the two groups (Table 3).

All students in the facility group (Group A) completed three proctored sessions lasting one hour each, totaling to 180 minutes. Over the three-week period, the portable trainer group (Group B) reported an average 204 minutes (range 30 - 330 minutes) of total practice. Time spent practicing was concentrated in the week prior to the post-test (average 102 minutes). Eight students practiced for more than 180 minutes in the portable trainer group. Practicing longer than 180 minutes, however, resulted in no improvement both subjectively and objectively when these students were compared with those who practiced for 180 minutes or less (Table 4).

Group A (facility group) performed statistically better than Group B when comparing post-test peg transfer and fuzzy ball exercise average times as well as the total post-test average times (see Table 5). There was no statistically significant difference in objective improvement between the two groups. However, in regards to subjective scoring improvement, Group A had a statistically significant improvement compared to Group B (4.6 point average increase vs. 2.4 point average increase, P=0.03). They had better average scores on the post-test peg transfer test and greater subjective score improvement.

Table 2. Baseline Demographics of Subjects

	Group A (N=14)	Group B (N=15)	*p* value
Females	6	7	1.0
Males	8	8	
Average Age in years (range)	24.2 (22-29)	26.4 (23-33)	0.03
Number of subjects who played ≥1hr/week of video games	9	5	0.14
Number of subjects who played musical instrument	8	11	0.45
Number of subjects who played organized sports	13	12	0.59
Average time practiced in minutes (range)	180	204 (30-330)	0.18

Group A= Standard laparoscopic trainer, Group B= Portable laparoscopic trainer

Table 3. Average Pre-Test Times and Average Scores

	Group A	*Group B*	p *value*
Fuzzy Ball Average Time (sec)	75	89	0.21
Fuzzy Ball Average Total Score (4-20)	10.5	10.1	0.83
Running the Bowel Average Time (sec)	75	107	0.34
Running the Bowel Average Score (4-20)	11.9	10.5	0.39
Peg Transfer Average Time (sec)	120	131	0.60
Peg Transfer Average Score (4-20)	12.1	10.7	0.11
Total Average Time (sec)	270	323	0.36
Total Average Score (4-20)	11.5	10.4	0.58

Group A= Standard laparoscopic trainer, Group B= Portable laparoscopic trainer

Table 4. Average Times and Scores and Average Change from Pretest to Post-Test Among Group B Based on Practice Time

	Practice ≤ 180 min	*Practice ≥ 180 min*	p *Value*
Average pretest total time (sec)	362	318	0.69
Average pretest score (4-20)	10.4	10.4	0.86
Average posttest total time (sec)	190	212	0.39
Average posttest score (4-20)	13	12.7	0.49
Total average time change (sec)	-172	-106	0.60
Total average score change	2.6	2.3	0.91

Group B= Portable laparoscopic trainer

Table 5. Average Post-test Times and Average Scores and Average Change from Pre-test to Post-test

	Group A	*Group B*	p *value*
Fuzzy Ball			
Average Time (sec)	36	49	0.009
Average Score (4-20)	14.8	13.1	0.17
Average Time Change (sec)	-38	-39	0.95
Average Score Change	4.3	3	0.15
Running the Bowel			
Average Time (sec)	55	72	0.07
Average Score (4-20)	15.2	13.6	0.19
Average Time Change (sec)	-20	-29	0.66
Average Score Change	3.3	3.1	1.00
Peg Transfer			
Average Time (sec)	52	79	0.01
Average Score (4-20)	18.2	11.8	<0.001
Average Time Change (sec)	-67	-52	0.42
Average Score Change	6.1	1.1	<0.001
Total			
Average Time (sec)	144	198	0.04
Average Score (4-20)	16.1	12.8	0.001
Average Time Change (sec)	-126	-120	0.45
Average Score Change	4.6	2.4	0.03

Group A= Standard laparoscopic trainer, Group B= Portable laparoscopic trainer

Students were surveyed during the pre and post-test on interest in surgery and prior sports, video game, or musical instrument experience. Students who played at least 1 hour/week of video games had statistically faster average times in the pre-test peg transfer exercise (108 seconds versus 142 seconds, P=0.02). They were also faster in the post-test fuzzy ball exercise (37 seconds versus 48 seconds, P=0.05). Previous musical instrument use and participation in sports showed no statistically significant difference in performance both subjectively and objectively.

Sixty-four percent of the students in Group A and 73% of the students in Group B had an interest in surgery at the time of the pre-test. By post-test survey, three students in Group A and six students in Group B reported being more interested in surgery at the completion of the study. Forty-three percent of Group A felt that the portable laparoscopic trainer group had the advantage in the study. Only 27% of the subjects felt the same in Group B (the portable laparoscopic trainer group). The primary barriers to training at home, as reported by Group B participants, were time management and boredom with the tasks.

Table 6 highlights the anonymous subjects' responses to the difficulty of the tasks and ease of use of the instruments. Interestingly, though Group A did subjectively and objectively better on most of the post-tests, they felt that the tasks and use of the instruments were more difficult after the completion of the study.

Table 6. Survey Information from Pre-test and Post-test

	Group A		*Group B*	
	Pre-test	*Post-test*	*Pre-test*	*Post-test*
Tasks were difficult	29%	43%	30%	27%
Difficult to use laparoscopic instruments	29%	50%	30%	7%
Difficult to use portable trainer laparoscopic instruments	N/A	N/A	N/A	27%

Group A= Standard laparoscopic trainer, Group B= Portable laparoscopic trainer

Discussion

Learning and mastering laparoscopic skills is essential for any surgical resident. However, teaching residents in the operating room is expensive and inefficient. A study done by Bridges and Diamond estimated the annual cost of training residents in the operating room to be $53 million[7]. Therefore many efforts are being made to teach and prepare residents outside the operating room in order to reduce this burden. Because of the steep learning curve, laparoscopic skills labs are becoming an integral part of surgical training.

Numerous studies have demonstrated that subjects who participate in laparoscopic skills labs improve their performances in the operating room[2]. With more stringent restrictions on working hours, taking time away from the operating room in order to participate in these labs becomes difficult for surgical residents. A study by Chang et al. found that residents chose not to participate in a simulation laboratory partly because of time and location[8]. They need a way to practice and improve their skills outside of the operating room and outside of the workplace. These two constraints make portable at-home trainers the ideal solution. Previous randomized trials found that portable at-home trainers are just as effective as the standardized facility trainers in improving performance[4,5]. Additionally, portable laparoscopic trainers are inexpensive and some can even be homemade[6,9]. Our study is the first to investigate and validate the TASKit trainer as another low cost alternative for laparoscopic training.

Most of the aforementioned studies used subjects with previous laparoscopic experience (residents, surgeons, physicians, etc.). Chandrasekerea et al. compared the standard pelvic trainer to a simple cardboard box model in medical students and found they were both effective in improving laparoscopic skill performance[10]. Our study also focused on medical students with no prior surgical experience. We wanted subjects who were equally inexperienced at baseline. In addition, the surgically naïve population stands to improve most from an inanimate laparoscopic skills trainer.

Palter et al. examined perception of different skills training models amongst residents with strong laparoscopic experience[11]. They found that these advanced residents preferred animal models or video trainers over virtual reality. When Hagen et al. surveyed general surgical residents, they responded that skills laboratories were more beneficial for junior residents[12]. This may be secondary to the fact that senior residents already have laparoscopic experience. Despite this, there was overwhelming agreement that laparoscopic simulators were beneficial and those who had an opportunity to train with simulators had overall better performance.

This was consistent with what was noted in our study. Both groups had improved performance even after a short 3-week training period. Will this improved performance on inanimate models translate to improvement in the operating room for surgical residents? Simon et al addressed this question in a randomized trial of surgical residents[13]. The group who completed 10 days of 30-minute training exercises had improved performances both on the video trainer tasks as well as in the operating room. On the other hand, Traxer et al. found that there was no difference in performance of a porcine laparoscopic nephrectomy between those who underwent a 10-day (30 minutes/day) course of inanimate skills training compared to controls[14].

The inferior subjective performance of the portable lap trainer group reinforces the importance of supervision and feedback. This suggests that junior residents and naïve subjects should first learn in the presence of professional experienced instructors before practicing on their own.

Proficiency targets have been found to be beneficial in improving performance in other studies. Gauger et al compared a group of surgical interns training on a laparoscopic simulation trainer with and without proficiency targets. They found that it not only improved practice and task performance but also improved operating room performance as well[15].

One way to provide proficiency targets and objective feedback is through the use of a virtual reality simulator[2]. Hamilton et al. compared two groups of residents who underwent a 2-week course (ten 30-minute sessions) of training on a standard trainer versus a virtual reality trainer[16]. There was no overall objective difference in their task performances at the end of the study, however, the virtual reality group performed better in the operating room. One explanation for this outcome was that the virtual reality trainers gave feedback on errors, economy of motion with both hands, and the economy of diathermy. Youngblood et al. found similar outcomes when they compared the LapSim virtual reality trainer to a standard Tower Trainer[17].

Despite this, the subjects in Hamilton's study and other studies have shown that participants prefer the standard box trainers over the virtual reality simulators[16, 18]. Virtual reality trainers are more expensive and less accessible than the standard box trainers. Other studies comparing the two modalities have shown that both trainers improve laparoscopic skills equivalently[, 20]. Madan and Frantzides found that when medical students were trained by both modalities they did better than either method alone[21].

Video assisted techniques are utilized in multiple specialties. In the field of orthopaedic surgery for example, arthroscopic simulation training has been studied with similar results. In a systematic review, Modi et al found 9 different studies which all validated the use of various computer-assisted simulation modalities[22]. Using inexperienced subjects, Andersen et al demonstrated improvement in virtual reality shoulder arthroscopy following a single training session[23]. However, few studies have shown transfer of simulation training skills to live arthroscopy. Howells et al developed a randomized controlled trial to address this. Twenty junior level residents participated in the study, with 10 subjects receiving training on box-type trainers. The simulation trained group scored significantly better in both subjective and objective measures[24].

Regardless of the specialty or type of laparoscopic trainer available, motivating students and residents to practice can prove to be difficult. In our study, the medical students who took the trainers home found that time management and boredom with the tasks were the two major barriers to practice. The inanimate trainers are designed to develop hand-eye coordination and familiarize the trainee with use of the instruments[25]. However they aren't effective in simulating dissection or higher level tasks which become more important for more advanced trainees.

As other studies have shown, we found that previous experience with video games impacted a subjects' performance in laparoscopic skills. Rosenberg et al. found that video game ability predicted the level of laparoscopic skills in novice subjects[26]. Grantcharov et al. also found that those who played computer games made fewer errors on a virtual reality simulator compared to non-users[27]. Madan et al. looked at medical students' performances on both a box trainer and virtual reality trainer. They found that computer game experience, typing, use of chopsticks, and musical instruments had no impact on predicting performance on the box trainer but did impact the virtual reality trainer scores[28]. Our study also found that previous musical instrument use and participation in sports didn't impact overall performance in laparoscopic skills.

Our study did generate more interest in surgical training at completion. This is important, as there is evidence suggesting that the number and quality of surgical residency applicants is declining[29]. As medical students choose their careers, early exposure to laparoscopic skills labs, whether through facility or portable trainers, may increase interest in surgery.

One of the weaknesses of the study was that the evaluators were not blinded to which group the subject was in. This could have affected their subjective scoring. In addition, the facility group may have had an advantage because they trained on the standard laparoscopic trainer, which was also used for pre- and post-testing.

Conclusion

After three weeks of training, both groups showed objective and subjective improvement. The portable trainer group reported longer average practice time than the facility group, but despite this, had less subjective improvement compared to the facility group. This suggests that surgically naïve students benefit most from proctored sessions to learn proper technique initially. This also suggests that even without guidance, naïve subjects are able to improve their laparoscopic skills using portable trainers.

Access to a portable trainer provides more time and convenience to practice, however our subjects reported difficulties with time management and boredom with the tasks. Further study is necessary to determine the best way to maintain interest in tasks and promote consistent practice. Some ideas to increase interest include surgical scenarios, competition with classmates, and more advanced tasks. As far as time management is concerned, it will be difficult to combat the human nature to procrastinate. However, weekly checkpoints or incentives may improve consistency of training. Further investigation is necessary to examine these two constraints to portable training.

Comparison of individual modalities has been examined here, but the effect of combination training has yet to be studied using the TASKit trainer. We may explore each modality versus combination in a future study.

Based on our survey data, exposure to laparoscopic skills labs has a positive impact on student interest in surgery. This suggests that studies similar to ours may help generate interest and maintain a high quality applicant pool in all fields of surgery.

Overall, our results suggest that inexperienced students should have several proctored sessions before using the home trainer to improve their laparoscopic skills. If instruction is not available, naïve subjects will still improve with portable training, but they generally spend more time and end up less proficient than those with proctored training. Continued research is necessary to determine what amount of initial proctored training produces the best result with a portable trainer.

Future Directions

The results of this study raise several questions. For instance, what is the best way to encourage training time in the at-home group? Adding incentives for hours completed would potentially increase the number of hours logged. Also, several participants found the tasks repetitive and failed to capture their attention for more than a few minutes. Creating new activities with set goals and achievements could potentially add to participant interest. The combination of these two aspects would not only enhance the at-home experience but would serve as a model for future trainers and training programs.

Level of laparoscopic experience was limited to naïve subjects in this case, but relative benefit of each training regimen could be examined in groups with varied experience. Senior residents view simulation exercises as more useful for junior residents with less experience. A future study could examine the effect of prior laparoscopic experience on subjective and objective improvement. We theorize that a plateau point would become evident where simulation would not significantly increase skill. The question is at what training level would this occur and would it be sooner with an at-home trainer versus the standard facility trainers? A study comparing residents grouped by post-graduate year randomized to at-home and standard trainer groups would help answer such questions.

Lastly, laparoscopic techniques are not unique to the field of Urology. Multiple specialties from general surgery to orthopaedics to gynecology rely heavily upon video-assisted techniques to treat disease. Developing at-home simulation training exercises specific to each specialty would help generate interest and encourage practice. Comparing these specialty-specific tasks to the current, more generic curriculum could provide insight into exactly what type of tasks are helpful for each specialty.

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