**ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:**

**‘‘ΕΛΑΧΙΣΤΑ ΕΠΕΜΒΑΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ,**

**ΡΟΜΠΟΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ ΚΑΙ ΤΗΛΕΧΕΙΡΟΥΡΓΙΚΗ’’**

**ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ**

**ΙΑΤΡΙΚΗ ΣΧΟΛΗ**

# ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

## ΘΕΜΑ:

## Assessment of laparoscopic surgical skills acquired on laparoscopic virtual reality simulator compared to box trainer: an analysis of obstetrics-gynaecology residents

**ΜΕΤΑΠΤΥΧΙΑΚΟΣ ΦΟΙΤΗΤΗΣ:**

**ΒΑΡΡΑΣ ΜΙΧΑΗΛ**

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# ΠΡΑΚΤΙΚΟ ΚΡΙΣΕΩΣ

## ΤΗΣ ΣΥΝΕΔΡΙΑΣΗΣ ΤΗΣ ΤΡΙΜΕΛΟΥΣ ΕΞΕΤΑΣΤΙΚΗΣ ΕΠΙΤΡΟΠΗΣ ΓΙΑ ΤΗΝ ΑΞΙΟΛΟΓΗΣΗ ΤΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ

**Του Μεταπτυχιακού Φοιτητή: Βάρρα Μιχαήλ**

***Εξεταστική Επιτροπή***

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Η Τριμελής Εξεταστική Επιτροπή η οποία ορίσθηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Παν. Αθηνών Συνεδρίαση της .....ης ................ 20.... για την αξιολόγηση και εξέταση του υποψηφίου κου Βάρρα Μιχαήλ, συνεδρίασε σήμερα ....../….../..........

Η Επιτροπή διαπίστωσε ότι η Διπλωματική Εργασία του Κου Βάρρα Μιχαήλ με τίτλο: «**Assessment of laparoscopic surgical skills acquired on laparoscopic virtual reality simulator compared to box trainer: an analysis of obstetrics - gynaecology residents»**, είναι πρωτότυπη, επιστημονικά και τεχνικά άρτια και η βιβλιογραφική πληροφορία ολοκληρωμένη και εμπεριστατωμένη.

Η εξεταστική επιτροπή αφού έλαβε υπ' όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους .................. προτείνει την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's Degree), στον παραπάνω Μεταπτυχιακό Φοιτητή.

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους ....................., για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους ...................., και για τον βαθμό «ΚΑΛΩΣ» ψήφους ................. Κατά συνέπεια, απονέμεται ο βαθμός «......................».

Τα Μέλη της Εξεταστικής Επιτροπής

- Νικόλαος Νικητέας, **Επιβλέπων** (Υπογραφή) ________________
- Χρήστος Π. Τσιγκρής, (Υπογραφή) ________________
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**… αφιερώνεται στην μνήμη του πατέρα μου …**

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# 1. Introduction

Laparoscopic surgery (LS) is the standard technique for an increasing number of operations. Minimized risk of infection, reduced pain, shortened rehabilitation time, and better cosmetic results are some of the major benefits compared with open surgery. However, LS requires a very different set of of psychomotor skills compared to open surgical approach since the differences in the sensory input, the different eye-hand coordination, the degradation of the image quality, the fulcrum effect of the very long laparoscopic instruments, the varying handles of laparoscopic instruments, the limited force feedback, the absence of 3D vision visualized on a 2D screen, the mirror images due to the backward camera angles and the reduction to four from six of the degrees of freedom [Champion et al, 1996, Gallagher et al, 1999, Rosser et al, 2000, Figert et al, 2001, Gallagher and Satava, 2002, Ali et al, 2002, Harold et al, 2002, Pearson et al, 2002, Seymour et al, 2002, Madan et al, 2003, Madan et al, 2004, Halvorsen et al, 2005, Madan and Frantzides 2007, Atul et al 2008].

Available types of simulation for teaching surgical skills include inanimate models, animal models, and virtual reality simulators. Laparoscopic surgical training using box trainers (or video trainers, VTs) and laparoscopic virtual reality (VR) simulators, overcomes the inherent differences between laparoscopic and open surgery and improves laparoscopic skills that subsequently are transferred to the operating room for surgical performances [Scott et al, 2000, Hasson et al, 2001, Madan et al, 2003, Madan et al, 2005, Gallanger et al 2005, Madan and Frantzides 2007, Kirby et al, 2008, Madan et al 2008a, Condous et al, 2009, Hiemstra et al, 2009**,** Zheng et al, 2010]. High-fidelity models with life-like patient anatomy are employed for the development of special psychomotor skills outside the operating theater [Bridges and Diamond, 1999, Gallagher and Satava, 2002]. A trainee is able to develop surgical skills and become familiar with a particular procedure in a surgical laboratory away from the operating room before operating for the first time on a real patient. In addition, new techniques and technologies are attempted in simulation models and not *de novo* on patients [Torkington et al, 2000, Torkington et al 2001a, Torkington et al 2001b].

However, there is a controversy about the superiority of laparoscopic VR simulators versus laparoscopic VTs on the transferability of laparoscopic skills because of the dissimilarity of the tasks performed on each device [Hamilton et al, 2002, Munz et al, 2004, Lehmann et al, 2005, Youngblood et al, 2005, Debes et al, 2010, Loukas et al, 2012].

# 2. Part One

## The Role of Laparoscopic Simulators in Developing and Assessing Laparoscopic Surgical Skills in Gynaecologic Laparoscopic Surgery

### 2.1. Introduction

The traditional method of obtaining technical skills in surgical specialties is based in the principle of “see one, do one, teach one” when the apprentice after observing a particular procedure for a first time, is expected to be able to perform that procedure without complications the next time and then is expected to be capable of training another apprentice how to perform effectively the same procedure. However, this method may not work in minimally invasive surgery, which involves working with images on a screen and instruments that are manipulated outside the line of vision and therefore the trainee is not able to observe the surgeon’s hands, the instruments and the operative results of manipulation simultaneously as it happens in open surgery [Melvin et al, 1996, Halvorsen et al, 2005]. In addition, there is a general concert if the patient’s safety is at risk when a resident perfom a surgical procedure after seeing it only once [Kotsis and Chung 2013]. Surgical outcome depends not only on the condition of the patient and the condition of the disease but most importantly on the condition of the surgeon [Patil et al, 2003, Halvorsen et al, 2005]. The surgeon must be very familiar with the anatomy, the patient selection, preparation and positioning, the equipment used during surgery and the postoperative care. The surgeons benefit from (a) observation and imitation, (b) deliberate practice with skill repetitions which are combined with structured training and informative feedback, and (c) adaptation for the final development of the necessary cognitive, affective and psychomotor surgical skills. The cognitive skills of a surgeon are the factual knowledge, clinical judgment, decision making and the ability of thinking and working under stress; the affective skills are compassionate and professional attitude and effective communication skills; the psychomotor skills are the perceptual motor skills and the physical movements of surgeon. With the observation and imitation the trainee enters the cognitive phase, after a deliberate practice enters the associative phase and with a combination of time and practice enters the autonomous phase. Furthermore, non-technical factors such as communication, teamwork and leadership play a substantial role in surgical success [Flood et al, 1984a, Flood et al, 1984b, Luft et al, 1979, Luft 1980, Luft et al, 1987, Taylor et al, 1997, Torkington et al, 2000, Cuschieri 2001, Birkmeyer et al, 2002, Patil et al, 2003, Halvorsen et al, 2005, Christian et al, 2006, Yule et al, 2006, Stevenson et al, 2007, Hamdorf and Hall, 2008, Mishra et al, 2008, Palter and Grantcharov, 2010, Munro, 2012, Thomas et al, 2014]. It has been suggested that acquisition of adequate knowledge and experience reduce the medical mistakes during surgery [Cooper et al 1978, McQuillan et al, 1998, Lighthall et al 2003]. The number of cases required to master a particular procedure, dependents on the learner, the trainer and the environment [Kolozsvari et al, 2011]. As regards the supervision of the residents during an operation, Itani et al (2005) found that the level of resident supervision in the operating room did not affect clinical outcomes adversely for surgical patients even when qualified surgeons were not present in the operating room, but were available if needed [Itani et al, 2005]. In a prospective randomized trial, Mahmoud et al (2012) showed that senior surgical residents were able to act without compromising patient safety as teaching assistants for junior residents under faculty supervision [Mahmoud et al, 2012]. The skill repetitions are important for the development of a comprehensive surgical curriculum. Moulton et al (2006) has suggested that practice of surgical residents on micro-vascular anastomoses over four weeks-time was superior to practice in one day [Moulton et al, 2006]. With the implementation of restricted work hours on clinical training during our days and the spending of less time in the operating room, the residents have to practice at simulation laboratories to attain equivalent experience [Karamanoukian et al, 2006, Samia et al, 2013]. McGaghie et al (2011) in a meta-analysis of fourteen articles showed that the simulation-based medical education with deliberate practice was more effective than the traditional clinical education [McGaghie et al, 2011].

Mininally invasive surgery compared to open surgery leads to a longer learning curve because it is more difficult to learn and master [Samia et al, 2013]. Over the past years, the use of surgical simulation in minimally invasive surgery outside the operating room has increased significantly for the acquisition of cognitive knowledge and surgical skills and for shortening the learning curves of the residents [Samia et al, 2013, Thomas et al, 2014]. It has been shown that delicated training on simulators of the surgical residents resulted (i) in improved technical performance in the operating room with fewer errors and injuries, (ii) in enhanced ability to attend to cognitive components of surgical expertise, (iii) in efficiency of movements during the operation and (iv) in significant decrease of operative time [Torkington et al, 2001, Seymour et al, 2002, Andreatta et al, 2006, Palter et al, 2011, Aggarwal et al, 2007, Samia et al, 2013]. In addition, the operating room is a suboptimal place for novice training in minimally invasive surgery as in variable cases with high complexity and high stress, the trainer often subconsciously guide the trainee or more usually take control away from the trainee and does not teach the series of events that are occurring in an attempt to keep control of the case and avoid errors or complications for the patient’s safety. This assistance is perceived by the trainee as a false sense of control and mastery because these are the parts of the procedure, in which the trainee needs the most guidance. Therefore, in such crucial times of an operation, simulation allows trainers to improve performance in a controlled setting outside the operation theater [Park et al, 2007, Moulton et al, 2010, Samia et al, 2013]. For all these reasons, any expense of training in the minimally invasive simulators of the residents in surgical specialties justifies further the prolonged time for training in the operating theater, which subsequently results in increase of the cost passed to patient and the health care system [Thomas et al, 2014]. In addition, the increasing awareness for medico-legal implications and the greater premise that it is ethically unacceptable for one to be surgically trained on real patients, further favors the development of a simulator-based surgical curriculum [Sadideen et al, 2012]. Furthermore, before surgical residency the simulation might be helpfull in the identification of the appropriate individuals who will become technically competent surgeons. Also, simulators might be usefull for the credentialing processes of surgeons for the reduction of the adverse events, analogous to the certification practice of commercial pilots [Halvorsen et al, 2005, Munro, 2012].

## 2.2. Surgical simulators for Training in Laparoscopic Surgery

Effective surgical simulators can be either task-specific or unique to a particular situation or surgery [Thomas et al, 2014]. The simulators should have a dual role, functioning both as training and testing platforms for the evaluation of surgeons [Munro, 2012]. Kneebone (2005) proposed four criteria for the simulation-based learning: (1) Simulations should allow for sustained, deliberate practice within a safe environment, ensuring that newly acquired skills are consolidated within a defined curriculum which assures regular reinforcement; (2) simulations should provide access to expert tutors when appropriate, ensuring that such support fades when it is no longer needed; (3) simulations should map onto real clinical experience, ensuring that learning supports the experience gained within communities of actual practice; (4) simulation-based learning environments should provide a supportive, motivational, and learner-centered milieu that is conducive to learning [Kneebone, 2005]. The concept of validity dictates the process of evaluation of a simulator and addresses the question of whether the measurements obtained from the simulator vary with the educational construct the simulator is intended to measure. There are five types of validities that are applicable to medical simulators: face, content, construct, concurrent, and predictive validity [Schijven and Jakimowicz 2002, Munro, 2012, Samia et al, 2013, Thomas et al, 2014]. Face validity determines the overall property of a task of the simulator intended to measure and addresses the question to “what extent does the simulator look like what it is supposed to simulate, e.g., the surgical procedure?” Face validity is usually assessed by the expertises’ in the field response to questionnaires and shows whether trainees accept or not the simulation as a valid educational tool [Munro, 2012, Samia et al, 2013]. Content validity reflects the extent to which the task of the simulator includes all relevant aspects of the techniques or procedure and addresses the question “does the simulator cover all the critical steps of the task under study?” Content validity is often assessed by interviewing expert surgeons. Face and content validity are subjective assessments of a simulator’s validity [Munro, 2012, Samia et al, 2013, Thomas et al, 2014]. Construct validity defines the extent to which the simulator measures what it is supposed to measure and demonstrate whether there is a statistical difference in performance measured between different groups with different experiences and skills. Demonstrating a significant difference in novices, senior residents, and expert surgeons’ scores demonstrates that the simulator correctly identifies quantifiable aspects of surgical skill. A simulator has construct validity, as a training system, if it results in improved task performance of a novice or trainee with an intermediate skill level to that of an expert [Munro, 2012, Samia et al, 2013, Thomas et al, 2014]. Concurrent validity measures the degree to which the simulator correlates with existing performance measures of the same surgical task or procedure, e.g. by another simulator of the same type that has previously undergone validation. It is necessary to have validated metrics to use for the process of comparison otherwise concurrent validation is not possible [Munro, 2012, McGaghie et al, 2011, Samia et al, 2013, Thomas et al, 2014]. Predictive validity measures the degree of which the test can correlate with other measures of a same type test at a later time in an operating room environment for outcomes that are thought to be associated with the safe and effective execution of surgical tasks and procedures and addresses the question “can the measured performance on the simulator predict the future performance in the operating room?” [Munro, 2012, Samia et al, 2013, Thomas et al, 2014].

One way to classify surgical simulators is based on the technology they use and are described as low- and high-tech simulators, while another way is based on the degree of their fidelity and evaluate characteristics like tactile and interaction feedbacks and visual clues. Low-tech simulators are not computer-driven and are either the synthetic models or the organic simulators comprising the human cadavers, the animal models and the harvested animal tissues, which are animal tissues attached to synthetic frames. Synthetic models are (i) the benchtop models designed to teach open surgical procedures and include the tasks for knot-tying, fascial closure and suturing and (ii) the video-box trainers or the tower trainers designed to teach minimally invasive procedures, which are typically portable, low cost, low maintenance and can be used repeatedly by multiple users [Hammoud et al, 2008, Palter and Grantcharov, 2010]. Video-box trainers include a box with a lid and holes cut on the lid for the trocars insertion. A laparoscope inside the box is connected with digital camera and provides video output to monitor on which the trainees are watching their own movements, while performing the teaching task. Laparoscopic instruments such as laparoscopic graspers and laparoscopic scissors are inserted through the trocars into the box, where the tasks are teached. These inexpensive models are designed to develop hand–eye coordination and bimanual dexterity and can simulate a variety of techniques such as laparoscopic peg transfer, circle cutting, intracorporeal and extracorporeal-suturing, knot-tying using prettied loop and clip-applying [Hammoud et al, 2008, Palter and Grantcharov, 2010]. Also, relatively cheap and easy to construct laparoscopic trainers have desined for residents who wish to develop their skills at home such as box models with optical systems based on two parallel mirrors or box models using HD webcam as the camera [Walczak et al 2014]. The system MISTELS (McGill Inanimate System for Training and Evaluation of Laparoscopic Skills) consists of 5 exercises performed in an endotrainer box (laposcopic rings transfering, laparoscopic cutting, laparoscopic ligating loop, laparoscopic intracorporeal and extracorporeal suturing) and is the core of the Fundamentals of Laparoscopic Surgery (FLS) program and mandatory for board certification by the American Board of Surgery [Fried et al, 2004]. The limitations of the synthetic models are in one hand the fact that they do not teach an entire operation but only one surgical technique and on the other hand the lack of objective assessment of performance as they need the presence of an expert to demonstrate the procedure and provide feedback on performance for the acquisition of the technical skills. The organic simulators are termed as ‘‘high fidelity’’ because of the closer proximity to the real-life situation. The human cadavers provide perfect anatomy, normal tissue consistency and a realistic operative training experience; however human cadavers are not portable, while other disadvantages are their limited number of availability, their loss of tissue fidelity compared with live models, their inability to simulate complications such as bleeding, their single use, some medical concerns for diseases transmission and ethical issues. The animal models provide realism during the operative training, give good practice in the maintainance of hemostasis and mimic complications, but they are expensive, have anatomical differences from the human body, require large facilities and veterinarian staff and have single use, while there are serious ethical concerns. The pig, goat, or other mammalian uterus, fallopian tubes and ovaries have no practical resemblance to those of women, making organic animal-based simulation of minimmaly ivasive procedures such as oophorectomy, myomectomy and hysterectomy essentially unfeasible. Harvested tissue models are perfect for training of skills that require many repetitions and provide haptic feedback. However, harvested tissue models provide the operation without perfusion, require special facilities for storage and are used only for limited procedures [Anastakis et al, 1999, Risucci et al, 2001, Kneebone 2003, Kneebone et al, 2006, Stefanidis et al, 2007, Porte et al, 2007, Xeroulis et al, 2007, Sarker and Patel 2007, Aggarwal et al, 2007, Hammod et al, 2008, Palter and Grantcharov, 2010, Grantcharov, 2010, Munro, 2012, Yiannakopoulou et al, 2015]. The hybrid trainers combine virtual-reality with video-box simulation, guide on how to perform entire operation, promote team based training, provide realistic haptic feedback as actual surgery and give metrics without the need of the presence of an experienced surgeon in order to give the trainee feedback. However, hybrid trainers are not portable and require facility, time and effort in preparation and maintenance [Halvorsen et al, 2005]. An example of a hybrid trainer is the ProMIS (Haptica Inc., Boston, Massachusetts, USA, www.haptica.com) wich aims the training of basic minimally ivasive surgical skills including suturing and knot-tying. Real instruments passed through ports enable manipulation of physical objects in a box simulator and provide real haptic feedback. ProMIS analyses performance by measuring time, path length, and smoothness and compares it to a defined proficiency level (Halvorsen et al, 2005). Another example of a hybrid trainer is the LapTrainer with SimuVision (Simulab Inc., Seattle, Washington, USA, www.simulab.com), which is an open box trainer with a simulated laparoscope (SimuVision) using a digital camera plugged into a laptop. This hybrid simulator has bundled four standardized exercises ranging from basic to more advanced laparoscopic skills (Halvorsen et al, 2005). Virtual reality simulation training in minimally invasive surgery has come to the foreground as a method of teaching surgical skills repeatedly with mistakes done without any risk to patient safety. Virtual reality (VR) trainers allow the learner to interact realistically with a computer-generated environment that comprise handles, foot pedals for diathermy, and other devices similar to those encountered in an actual operating room environment and can include additional sensory information such as sound and haptics for the provision of a sense of force feedback to simulate touch. Significant advantages of VR systems are their ability to recreate individual basic surgical skills e.g. knot-tying, suturing, dissection, moving cubicles or cutting off edges of squares or to recreate surgical skills of entire procedures along with possible procedural complications in a realistic setting with advanced graphics. They provide objective metrics on a vast majority of parameters by registering for example, the number of hand movements required to perform one stitch or the time taken to tie an intracorporeal knot or even providing information regarding the security of the knot without the presence of a teacher, thus improving operating room performance and patient outcome. Furthermore, the modern virtual reality trainers give the possibility to train surgeons for making the right decision [Haluck and Krummel, 2000, Kneebone et al, 2004, Kneebone et al, 2006, Halvorsen et al, 2005, Tavakol et al, 2008, Munro, 2012]. During the last years, a number of VR trainers with varying complexity for different medical fields have become commercially available including Simendo (Simulator for endoscopy) (DeltaTech, Delft, Netherlands, www.simendo.nl), Lapmentor simulator (Simbionix Inc., Cleveland, Ohio, USA, www.simbionix.com), LapSim (Surgical Science Lmt., Gothenburg, Sweden, www.surgical-science.com), Surgical Education Platform (SEP) (SimSurgery, Oslo, Norway, www.simsurgery.no and Medical Education Technologies Inc., Sarasota, Florida, USA, www.meti.com), Procedicus MIST TM (Mentice AB, Gothenburg, Sweden, www.mentice.com), EndoTower (Verefi Technologies Inc., Elizabethtown, Pennsylvania, USA, www.verefi.com), Reachin Laparoscopic Trainer (Reachin Technologies AB, Stockholm, Sweden, www.reachin.se) and Vest System (Virtual Endoscopic Surgical Trainer) (Select-IT VEST Systems AG, Bremen, Germany, www.select-it.de). Thus, VR simulators can be incoporated into the curriculums of anesthesiology, interventional radiology and ultrasonography, obstetrics and gynecology, general surgery, cardiovascularal surgery, orthopaedic, urology, internal medicine, emergency case, ear-nose throat or eye surgery [Halvorsen et al, 2005, Chalouhi et al 2014, Tay et al, 2014, Trehan et al, 2014, Brewin et al, 2014]. Another laparoscopic simulator system is the augmented reality (AR) laparoscopic simulator, which refers to systems that overlay computer graphics images and real video images into a single perception of an enhanced world around the user. Augmented reality connects both worlds: the virtual and the real world. Augmented reality simulation is the combination in one system of the physical and virtual reality. Some of the augmented reality laparoscopic simulation approaches are (i) the anatomical overlays, (ii) the visual pathway of the instruments, (iii) the realistic haptic feedbacks, (iv) the realistic training environment which is based on real instruments, which interact with real objects and (v) the objective assessment at the end of the performance of the trainee. The laparoscopic task is demonstrated by a video on the screen and after the trainee's performance there is an objective assessment without the need for an expert laparoscopic surgeon to observe and guide the trainee during the training. Over the recent years, several augmented reality simulators have been developed with an example the ProMIS AR laparoscopic simulator [Sanne et al, 2007, Sanne et al, 2009, Botden et al, 2009].

## 2.3. Scoring Systems to Objectively Assess the Acquired Skills from Laparoscopic Surgical Training

Different specific tools for the intraoperative assessment of the laparoscopic skills have developed. The Global Assessment of Laparoscopic Skills (GOALS) tool was developed by Vassiliou et al (2005) to assess laparoscopic depth perception, bimanual dexterity, efficiency, tissue handling, and autonomy [Vassiliou et al, 2005]. The GOALS tool has been validated for the assessment of basic laparoscopic skills [Vassiliou et al, 2005], laparoscopic cholecystectomy [Vassiliou et al, 2005], appendectomy [Vaillancourt et al, 2011] and inguinal hernia repair [Gumbs et al, 2007]. The observational clinical human reliability analysis (OCHRA) tool is an analysis method that is specialized in counting errors and near misses enacted during surgery by analyzing operative videos. It has been validated in assessment of laparoscopic colorectal skills [Miskovic et al, 2012]. Similarly, the Objective Structured Assessment of Technical Skills (OSATS) for laparoscopic skills has good construct validity [Swift and Carter, 2006].

## 2.4. Effectiveness of Surgical Stimulation in Laparoscopic Training

The evidence for effective laparoscopic learning using simulators has been proved by many studies. As regards the synthetic training tools Traxer et al (2001) in a blinded, randomized controlled trial of urological surgeons inexperienced with laparoscopy found that practice on a video-trainer resulted in a statistically significance reduction in time as measured on the simulator and in an improvement of their technical ability as measured by a validated global assessment tool in a porcine laparoscopic nephrectomy model as compared with a no-training control group [Traxer et al, 2001]. Similarly, transfer validity to animal models has been shown by Fried et al (2004) and Sidhu et al (2007) or to human cadavers by Anastakis et al (1999) and to the operating room by Scott et al (2000), and Hamilton et al (2001) [Anastakis et al 1999, Fried et al 2004, Sidhu et al 2007, Scott et al, 2000, Hamilton et al, 2001]. Many trials have examined the role of virtual reality (VR) simulators in teaching technical laparoscopic skills. Seymour et al (2002) demonstrated in a prospective, randomized, blinded study the validation of transfer of training laparoscopic skills from virtual reality to the operating room of residents during laparoscopic cholecystectomy [Seymour et al, 2002]. Similarly, Sroka et al (2010) showed that proficiency training with the Fundamentals of Laparoscopic Surgery (FLS) simulator resulted in an improvement of performance of junior residents during laparoscopic cholecystectomy [Sroka et al, 2010]. McCuney (2007) using the FLS system showed that that laparoscopic simulator performance independently predicts intraoperative laparoscopic skills as measured by the Global Operative Assessment of Laparoscopic Skill (GOALS) [McCuney 2007]. In addition, Stefanidis et al (2008) showed that the group randomized to FLS suturing model demonstrated significant improvement in performance on a live porcine laparoscopic Nissen fundoplication model [Stefanidis et al, 2008]. There are some evidence that proficiency-based training on simulators results in durable improvement of minimally invasive surgical skills of trainees even in the absence of ongoing practice on simulators or on the operation theater [Stefanidis et al 2005, Stefanidis et al 2008, Rosenthal et al 2010, Edelman et al, 2010, Mashaud et al, 2010]. Haptic systems are an advancement that provides tactile feedback to the trainees practicing on virtual-reality simulators and they feel the force on their instruments. Therefore, the haptic systems provide higher degree of realism to the simulators. However, the haptics-enhanced simulators have an increased cost and Thompson et al (2011) in a study for novices showed no improvement in efficiency or effectiveness of simulation training in minimally invasive surgery [Thompson et al, 2011]. Also, Panait et al (2009) investigated the role of haptic feedback in laparoscopic simulation training among medical students with minimal laparoscopic experience and similar baseline skill levels and found that haptic enhanced simulation did not demonstrate an appreciable performance improvement for the laparoscopic peg transfer task [Panait et al, 2009].

## 2.5. Laparoscopic Virtual Reality Simulators versus Laparoscopic Box-Trainers

In the English literature is not clear if the virtual reality simulation based training have some demonstrable advantages over the box trainers in the development of minimally invasive surgical skills for the justification of their increased cost [Beyer-Berjot and Aggarwal 2013]. Munz et al (2004) compared the performance of medical students who were tested in baseline tasks (laparoscopic circle cutting and laparoscopic clipping) between the LapSim VR simulator and the classical laparoscopic box trainer and found no significant differences between the groups [Munz et al 2004]. Also, Newmark et al (2007) found equivalent outcome for the measurement of time to task completion and number of errors after the training of medical students on LapSim VR simulator or on a video box trainer [Newmark et al 2007]. Moreover, Debes et al, (2010) examined the transferability of basic laparoscopic skills between a VR simulator (MIST-VR) and a video trainer box (D-Box) in medical students and found that both simulators provide significant improvement in performance and skills learned on the MIST-VR are transferable to the D-Box better than D-box to VR [Debes et al, 2010]. Similarly, Diesen et al, (2011) found that both laparoscopic box trainers and laparoscopic VR simulators were equally effective for teaching laparoscopic skills to novice learners [Diesen et al 2011]. Tanoue et al (2008) compared the effectiveness of medical students training on MIST-virtual reality (VR) simulator and laparoscopic box trainer for the fundamental skills of endoscopic surgery and found that both laparoscopic VR and box trainers had (i) better performance than controls and (ii) different outcomes at training different skills [Tanoue et al, 2008]. Madan and Frantzides (2007) found the combination of laparoscopic VR and laparoscopic box trainer to be superior to either system used alone in their study on preclinical medical students without prior operative experiences [Madan and Frantzides 2007]. In contrast, Hennessey and Hewett 2014 concluded that testing with low-fidelity FLS box trainer appears to demonstrate greater validity than the high-fidelity Lapsim virtual reality laparoscopic simulator [Hennessey and Hewett 2014]. Hamilton et al. (2002) compared the impact of VT against VR on surgical technical skills in the operation room during a laparoscopic cholecystectomy procedure of 19 second-year residents assessed before and after a training sessions and found the operative performance to be improved only in the laparoscopic VR training group [Hamilton et al. 2002]. However, the limitations to that study were (i) the training sessions were not supervised and feedback was given only to trainees on VR simulators by the metrics, while the trainees on VT had no feedback on VT apart from the time taken and (ii) all trainees were not assessed by the same surgeon as a training group, and individually before and after the training [Beyer-Berjot **L,** Aggarwal **R, 2013].** Beyer et al (2011) compared two groups of training on simulators; the first group was trained on the VR-LAP Mentor and the second group was tested on a simple VT with the Mac Gill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS). Both groups compared to a control group during a laparoscopic cholecystectomy in the operation room. Both intervention groups demonstrated a better progression compared to the control group, but there were no significant differences between the VT- LAP Mentor and the MISTELS groups [Beyer et al, 2011]. Youngblood et al (2005) compared the impact of the VT (Tower Trainer®, Simulab Corporation Seattle, WA, USA) and the LapSim® on surgical technical skills in live pigs between surgically naive medical students. They found superiority on live surgical tasks of the LapSim group compared with those trained with a traditional box trainer [Youngblood et al, 2005]. However, the limitations of the study were (i) the absence of baseline testing to ensure that both groups were comparable and (ii) the assessment tool was not a validated score [Beyer-Berjot L**,** Aggarwal R, 2013]**.**

## 2.6. Evidence for Training with Laparoscopic Simulation in Gynaecologic Laparoscopic Surgery

Although the operative laparoscopy in gynaecology was popularized in 1970s with the tubal sterilization, later in 1990s the laparoscopic procedures were introduced in the main stream and then synthetic simulators have been used to assess validity of gynaecologic tasks in simulation laboratories [Bharathan et al, 2014]. Kolkman et al (2008) have tested an inanimate laparoscopic box trainer for construct validity of five tasks between laparoscopic novices and advanced gynaecologists. After the baseline evaluation of novices and experts, the novices were assigned to five weekly training sessions (training group) or no training (control group) and both groups were retested. The experts were tested once, and their performance was compared with the baseline scores of all novices. The authors found that the training group improved significantly in all tasks and concluded that novices are able to reach the experts' basic laparoscopic skills level on the simulator after a short and intense simulator training course [Kolkman et al, 2008]. Also, Molinas et al [2008] developed a trainer box for the laparoscopic skills testing and training (LASTT) of 3 basic tasks: (i) camera navigation, (ii) camera navigation and forceps handling, and (iii) forceps handling and bimanual coordination. The authors found construct validity between 10 experts and 14 novices; this finding was also confirmed in a larger study during skill evaluation workshops organised by the European Academy of Gynaecological Surgery comprising 42 experts and 241 novices [Molinas et al, 2008]. In addition, Arden et al 2008 validated the innovative Pelv-Sim trainer for gynecologic laparoscopic suturing with 4 laparoscopic tasks: (i) closing an open vaginal cuff, (ii) transposing an ovary to the pelvic sidewall, (iii) ligating an infundibulopelvic ligament, and (iv) closing a port-site fascial incision between obstetrics and gynaecology residents and third-year medical students. All participants were timed as they completed the 4 tasks, and their performances were compared. The residents were then randomized to a study group asked to train with the Pelv-Sim for 1 hour per week for 10 weeks, or to a control group. To evaluate the effectiveness of training with the Pelv-Sim model, both groups of residents were retested at the end of the 10-week study period. Pre-training and post-training performances were compared within each group. The authors found that before the intervention, the residents completed all 4 tasks in significantly less time than the medical students. When retested after the 10-week study period, the control group showed no significant performance improvements. The trained group showed significant improvement in performance for the vaginal cuff closure task and the ovary transposition task, but not for the infundibulopelvic ligament ligation or the fascial closure tasks [Arden et al, 2008]. Gynaecologists from the Gynaecologic Oncology Division of the University of Washington (Seattle, WA) have conducted several studies to validate surgical skills in residents using a 6-station objective structured assessment process of technical skills (OSATS) including laparoscopic (salpingostomy, intracorporeal knot, and ligation of vessels with clips) and open abdominal procedures (subcuticular closure, bladder neck suspension, enterotomy repair, and abdominal wall closure). They concluded that OSATS is a reliable and valid method to assess surgical skills administered in either a blinded or unblinded fashion and can easily be administered in most residency programs [Goff et al, 2002, Mandel et al, 2005, Goff et al, 2005]. Tunitsky-Bitton et al (2014) created a cost-efficient surgical model for training in the key steps of performing laparoscopic sacrocolpopexy using as materials vaginal manipulator stent, stent cover, sacrocolopexy tip, RUMI advanced uterine manipulation system and the Fundamentals of Laparoscopic Surgery (FLS) box trainer. The construct validity was measured by comparing the performances on the model between experts and trainees. The authors conclude that this model has construct validity as the experts performed significantly better than the trainees in total score and in every domain of the Global Operative Assessment of Laparoscopic Skills scale versus trainee group. In addition, previous surgical experience had a strong association with performance on the model [Tunitsky-Bitton et al 2014].

A number of researchers have investigated the validity of VR simulators in gynaecologic laparoscopic surgery. Lentz et al (2001) assessed to 36 residents six laparoscopic tasks including running the bowel, bead transfer, manipulating intracorporeal sutures, peg transfer, running a pipe cleaner, and tissue handling using a simulator (Tap Pharmaceutical Products, Inc., Lake Forest, IL). Residents were timed at each given station and were given a rating score by 2 examiners. Assessment of construct validity demonstrated significant differences on the rating of overall performance and individual tasks by residency levels [Lentz et al 2001]. Gor et al (2003) suggested that the Minimally Invasive Surgery Trainer-Virtual Reality (MIST-VR) simulator provides objective assessment of laparoscopic skills in gynaecologists [Gor et al, 2003]. Hart et al studied 5th-year medical students, junior doctor trainees, and senior doctor trainees. Standard gynecologic procedures before and after MIST-VR training were undertaken on sheep. The procedures of salpingotomy, salpingectomy and clip sterilization were video-recorded and were scored by an independent observer blinded to the name and seniority of the participant using a combination of operative time and penalties for surgical errors while undertaking salpingectomy, salpingotomy, and tubal clipping. The higher the score, the better the surgical procedure was performed. The participants then undertook a number of practical sessions on the VR equipment over a 2-month period. The VR scores were recorded and scored by software using the default scoring algorithm. The authors found that the baseline VR scores were significantly related to the overall pre-training scores and also, a better initial VR score was predictive of better surgical performance [Hart et al, 2006]. Moore et al (2008) evaluated whether performance on the MIST-VR simulator reflects laparoscopic experience among gynecologic surgeons, trainees or medical students and found that increased operating room experience and age were associated with worsening simulator performance. The authors speculated that one possible explanation for the observed trend might be the result of laparoscopic experience in the operating room, with tactile feedback in the more experienced participants [Moore et al, 2008]. Larsen et al (2006) demonstrated construct validity for LapSim VR simulator in basic tasks of lifting and grasping, cutting, and clipping [Larsen et al, 2006]. Schreuder et al (2009) demonstrated for LapSim VR simulator construct and face validity as well for camera navigation, instrument navigation, coordination, sterilization, and closure of the myomectomy wound [Scheuder et al, 2009]. Furthermore, Schreuder et al (2011) found face and construct validity for the Simendo-VR simulator in an advanced virtual reality curriculum for intermediately skilled laparoscopic surgeons [Schreuder et al 2011]. There are some publications in which the salpingectomy module on the LapSim VR simulator has been assessed in terms of its validity as a training and assessment tool for gynaecologists.  Aggarwal et al (2006) in a prospective cohort study divided the participants into three groups as novice with less than 10 laparoscopic procedures, intermediate with 20 to 50 laparoscopic procedures and experienced with more than 100 laparoscopic procedures. All of them had to perform ten repetitions of the virtual ectopic pregnancy module and their operative performance was assessed by time taken to perform surgery, blood loss and total instrument path length. The authors found statistically significant differences between groups at the second repetition of ectopic module for time taken, total blood loss and total instrument path length. However, the learning curves of the experienced operators plateaued at the second repetition, while seven repetitions were necessary for intermediate and nine for novice surgeons to achieve similar levels of skills [Aggarwal et al, 2006]. Similarly, Larsen et al (2006) showed that expert gynecologists during the second session, performed significantly better than intermediate and novice gynecologists in terms of time, path length, and total score [Larsent et al, 2006]. These are also confirmed by Schreuder et al (2009). The opinion of subjects resulting from the questionnaire about the realism and training capacities of the tasks was favorable among all groups [Schreuder et al, 2009]. Therefore, gynaecologists with minimal laparoscopic experience can improve their skills during short-phase training on a VR procedural module. It seems that VR simulation is useful for the early part of the learning curve for gynaecologists, who wish to learn to perform laparoscopic salpingectomy for ectopic pregnancy.

Tang et al (2011) describes the design of a training phantom that enables trainees to practice key skills and steps used for the procedures of laparoscopic salpingotomy and laparoscopic salpingectomy. In this module the porcine small bowel is used to simulate the fallopian tube, while porcine liver and red food dye blended in a hand blender are used to simulate ectopic pregnancies inside the fallopian tube; mesentery imitates mesosalpinx. The authors conclude that this animal tissue model of laparoscopic salpingostomy and laparoscopic salpingectomy in ectopic pregnancy is realistic, cost-effective, and simple enough to be produced for use in laboratory-based surgical training courses [Tang et al, 2011]. Levine et al (2006) suggests a lightly embalmed human cadaver model for practicing laparoscopic surgical techniques for adnexal surgery, pelvic dissection, laparoscopic hysterectomy, and dissection within the space of Retzius. The training efficacy of this model was demonstrated using an physical-reality simulator for three outcomes (bead transfer time, number of beads transferred, and suturing time on a stuffed vinyl glove), and an embalmed cadaver pelvis for suture placement in two specific areas, with one slightly more difficult than the other. The residents showed significant improvement after the course in relation to baseline testing in a relatively short time [Levine et al 2006]. A live porcine model for teaching advanced laparoscopic skills in gynaecologic oncology fellows has determined by Hoffman et al (2009) to be a good model for laparoscopic lymphadenectomy, uretero-neo-cystostomy, repair of vascular injury, bowel anastamoses, distal pancreatectomy, nephrectomy, partial hepatectomy, diaphram stripping, and diaphragmatic resection. However, this model seems to be inadequate for other surgical procedures such as liver mobilization and splenectomy [Hoffman et al 2009].

## 2.7. In summary

Laparoscopic surgical training using simulation has many advantages such as (i) it is a patients' risk-free environment, (ii) it provides novice training in variable cases with high complexity, (iii) it gives immediate feedback of the training tasks (iv) it is ethically unacceptable because the training is not performed on real patients, (v) it is helpful in the identification of the appropriate individuals who will become technically competent surgeons, (vi) it is useful for the credentialing processes of surgeons for reduction of adverse events, (vii) it ensures the residents with less practical time in the operating room for improvement of their psychomotor and cognitive skills. Different simulators are used for these purposes including laparoscopic box trainers, laparoscopic VR simulators, animal models, human cadavers and lightly embalmed human cadavers with their effectiveness to be shown by many researchers although some controversies exist. The clinical training curriculum of obstetricians-gynaecologists should include laparoscopic VR simulators through an integrated evidence-based, simulation-based education program due to the growing request for advanced laparoscopic gynaecologic surgery with adjustment of innovative techniques in order to ensure high-quality laparoscopic training.

# 3. Part Two

## 3.1. Aim

The aim of the study was to determine the impact of training on LapVR simulator compared to laparoscopic box trainer on the improvement of the laparoscopic surgical skills assessed by the trainees' performance in two standard laparoscopic gynaecological procedures of laparoscopic salpingotomy and laparoscopic salpingectomy for ectopic pregnancy on the LapVR surgical model before and after the designed training modules.

## 3.2. Materials and Methods

The study was carried out at the laboratory of Medical Physics of the Medical School of the National and Kapodistrian University of Athens. The training was scheduled during the afternoons after the hospital working hours of the participants. 20 residents in training for Obstetrics and Gynaecology at the "Elena Venizelou" General Maternity State Hospital, Athens, Greece were recruited for voluntary participation. The name of the trainee, status and date of the test were entered on the pre- and post- assessment forms. The participant's demographics, laparoscopic training experience on LpVR, box trainers, animals or cadavers and laparoscopic theatre experience were evaluated. Written informed consent was obtained prior participation. Throughout the course of the study the participants did not have knowledge of their performance scores. Before pre-assessment, all participants received an identical instructional tutorial by the test supervisor to familiarize themselves with the equipments and the type of psychomotor skills involved in both laparoscopic simulator and box-trainer. The VR equipment tested used throughout this study was the **Immersion LapVR laparoscopic simulator** (Immersion Inc., San Jose, CA, USA). A description of the equipment is given by Iwata et al (2011) [Iwata et al, 2011]. This equipment has been suggested as an effective educational tool (**Figure 3.2-1**).

**Figure 3.2-1.** The **Immersion LapVR laparoscopic simulator**

**(Immersion Inc., San Jose, CA, USA).**

This VR trainer accurately measures the time taken to undertake the tasks and also scores errors and inaccuracies (**Figure 3.2-2**). In addition, the system possesses haptic feedback.

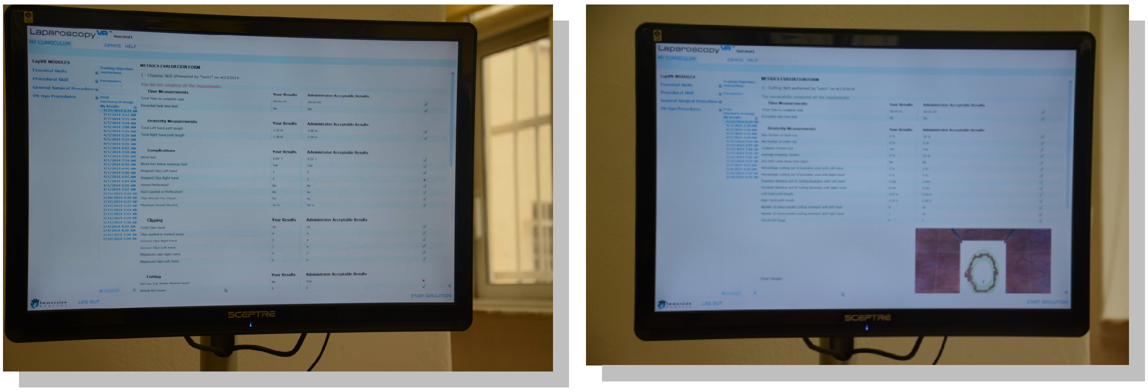


**Figure 3.2-2.** The LapVR laparoscopic simulator measures performance parameters at the end of each task.

During the pre-assessment task, the surgical skills of the participants were evaluated for analysis by measuring their ability to perform the two routine gynaecologic procedures of salpingotomy and salpingectomy for ectopic pregnancy on Lp-VR surgical simulator and the participants received minimal or no guidance during this run. After finishing the pre-assessment task, the participants were randomly divided in two Groups (Group A and Group B) with 10 participants for each group. The participants in Group A were trained on the laparoscopic VR equipment in two instructional sessions, one and half hours for each session. In a virtual reality environment, the “laparoscopic peg transfer”, “laparoscopic clip a vessel” and “laparoscopic cutting” tasks were used. Both hands of the participants manipulated the instruments during these tasks.

The participants in Group B were practiced on the laparoscopic box-trainer for one and half hours with training in the “laparoscopic ovarian cystectomy” and “laparoscopic salpingotomy” models. With the box-trainer, a laparoscopic tower was used containing an external monitor, a light source, a chip camera with its coupler, a video recorder and all the appropriated cables. The box-trainer contained two 5-mm working ports, approximately 18-cm apart and a third 12-mm port for visualization using a 10-mm laparoscope zero degrees fitted with the light cord adapter. Also, the camera was fitted to the laparoscope and connected to the external monitor. The camera was positioned in a standard location and the participants could instruct the camera during the completion of the tasks. All the exercises in the trainer box were recorded in CD-ROMs and subsequently were scored blinded to the name of the participant.

At the completion of the training on the LaVR and box trainer (post-assessment tasks), all participants were scheduled to undergo a second skills assessment on LaVR surgical simulator performing the same tasks of laparoscopic salpingotomy and laparoscopic salpingectomy. Additionally, at the end of the post-assessment tasks, all participants completed a structured questionnaire to assess their satisfaction and the validity of the models using a Likert scale (1 to 5-scale).

## 3.1. Participant's characteristics

The demographic and laparoscopic experience characteristics of the participants are shown in the **Table 3.2-1**. None of the participants had prior experience with the virtual reality simulator.

**Table 3.2-1. Demographic and laparoscopic-experience characteristics of the participants.**

| |
|---|
| **Age** |
| **Year of Training in Obstetrics and Gynecology** |
| 1st year |
| 2nd year |
| 3rd year |
| 4th year |

**Previous laparoscopic training experience**

No

LpVR stimulators

box trainers

live animals

cadavers

**Previous laparoscopic theatre experience**

Surgeon

Assistant

**Dominant hand**

Right

Left

Ambidextrous

**Play Videogames**

Yes

No

**Play musical Instrument**

Yes

No

**Play team sports**

Yes

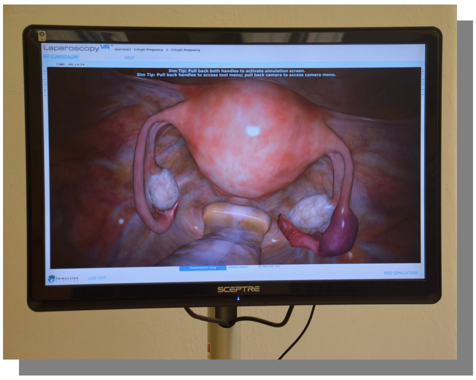
No

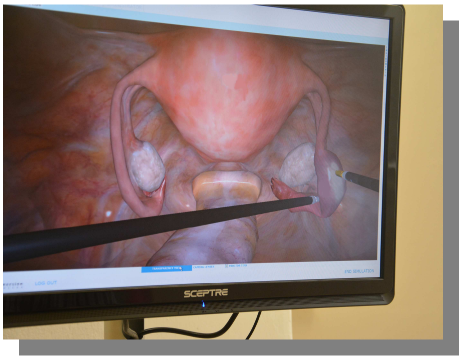
## 3.2. Description of the Tubal Ectopic Pregnancy Module on the Laparoscopic LapVR Simulator

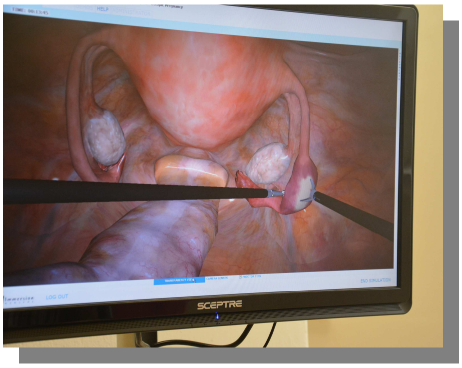
The “laparoscopic salpingotomy” and “laparoscopic salpingectomy” for ectopic pregnancy tasks of the LapVR laparoscopic simulator were used for the pre-training and post-training assessments of the participants (Ectopic Pregnancy 1 - Salpingotomy case 1 and Ectopic Pregnancy 1 - Salpingectomy case 2 respectively).

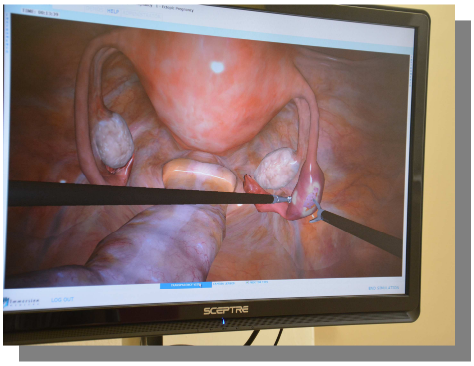
### 3.2.1. “Laparoscopic Salpingotomy” task on the Laparoscopic LapVR Simulator

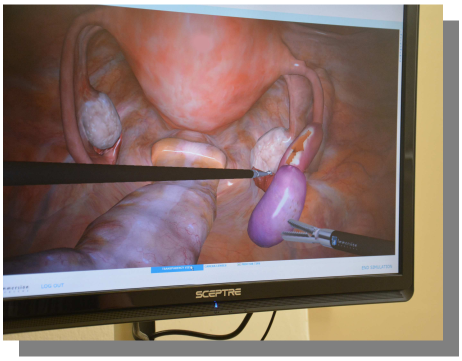
The user begins with survey of anatomy. The user grasps and holds the tube with an atraumatic grasper on its anti-mesosalpingeal border either proximal or distal to the ectopic section. The dominant hand instrument is changed to scissors or needle-tip monopolar cutting device in preparation for making the incision. A 2-cm longitudinal incision is made on the anti-mesosalpingeal border over the proximal portion of the EP site. The tube is held in place with graspers at the incisional border.

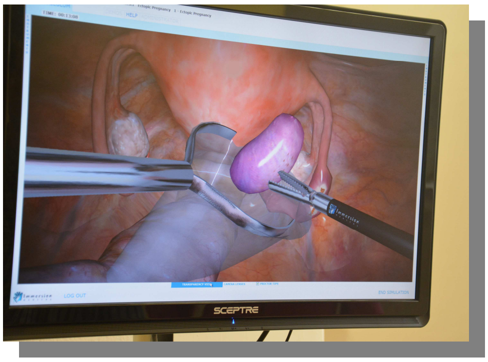












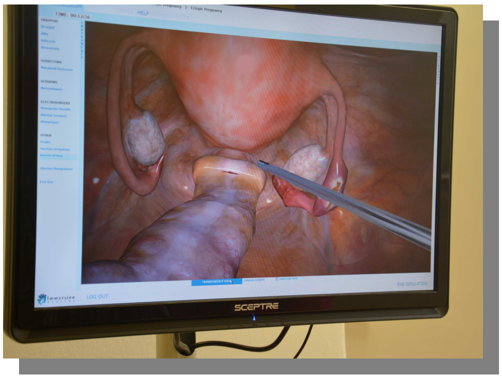


**Figure 3.2-3.** Presentation of the Laparoscopic surgical steps of the "Laparoscopic Salpingotomy" for ectopic pregnancy task on the LapVR laparoscopic simulator **(LapVR Tast: Ectopic Pregnancy 1 - Salpingotomy case 1).**

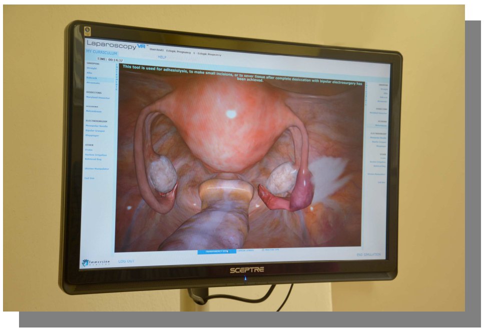
The incision is continued until the trophoblast or hematosalpinx appears. The incision should not be more than 2-cm in length or 1-cm in width. If the pregnancy does not protrude after making the incision, the user may make an instrument change to suction-irrigation device and attempt hydro-dissection with saline. The user places all tissue in retrieval bag. Once the tissue is placed in the bag, the user must pull the instrument all the way back and change instruments in order to remove tissue. The user cauterizes any active bleeders along the incision and irrigates to check for bleeding. The user cleans up operative area by suctioning blood from the cul-de-sac (**Figure 3.2-3**) and the simulation ends. The performance parameters are measured by the system at the end of the task. The following parameters were assessed:

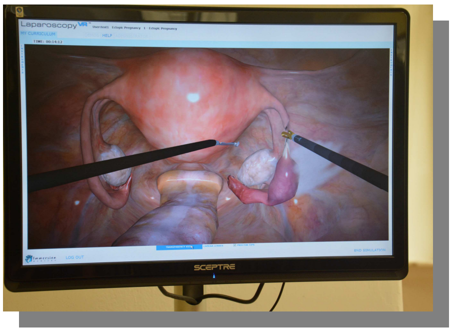
- **The Time to Complete the Task** → … **(in minutes)**
- **The Time for Cautery Used** → … **(in seconds)**
- **The Time for Cautery Used in Air** → … **(in seconds)**
- **The Total Blood Loss** → … **(in cc)**
- **The Incision Length** → … **(in cm)**
- **The Left Path.Length** → … **(in meters)**
- **The Right Path Length** → … **(in meters)**

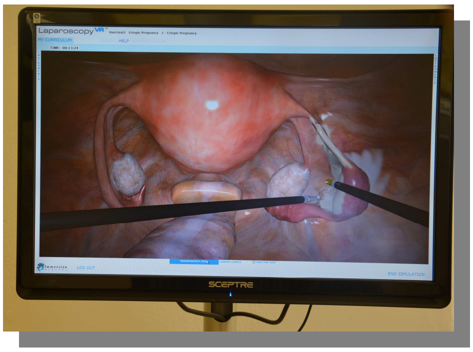
### 3.2.2. "Laparoscopic Salpingectomy" on the Laparoscopic LapVR Simulator

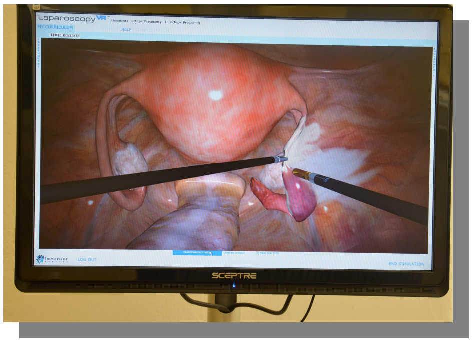
The second gynaecologic procedure is laparoscopic salpingectomy for ectopic pregnancy. Available instruments are graspers, bipolar graspers, scissors and irrigation-suction device. In this procedure, an ectopic pregnancy with tubal adhesions has to be dissected from the fallopian tube, the adhesions and the surrounding membranes.

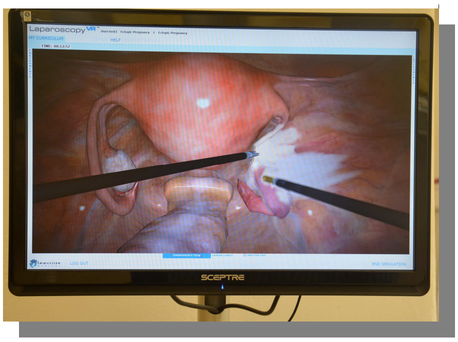
The user begins just distal to the cornual area of the affected tube using bipolar electrosurgery and coagulates 2-3 successive overlapping passes until a 2-3-cm area is desiccated. Scissors are used to cut through the middle of cauterized area. Again, performance parameters are measured by the the system at the end of the task. The user begins with survey of anatomy.

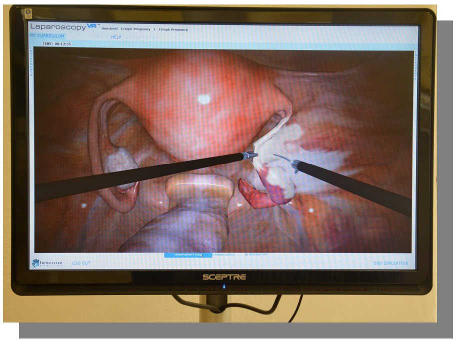












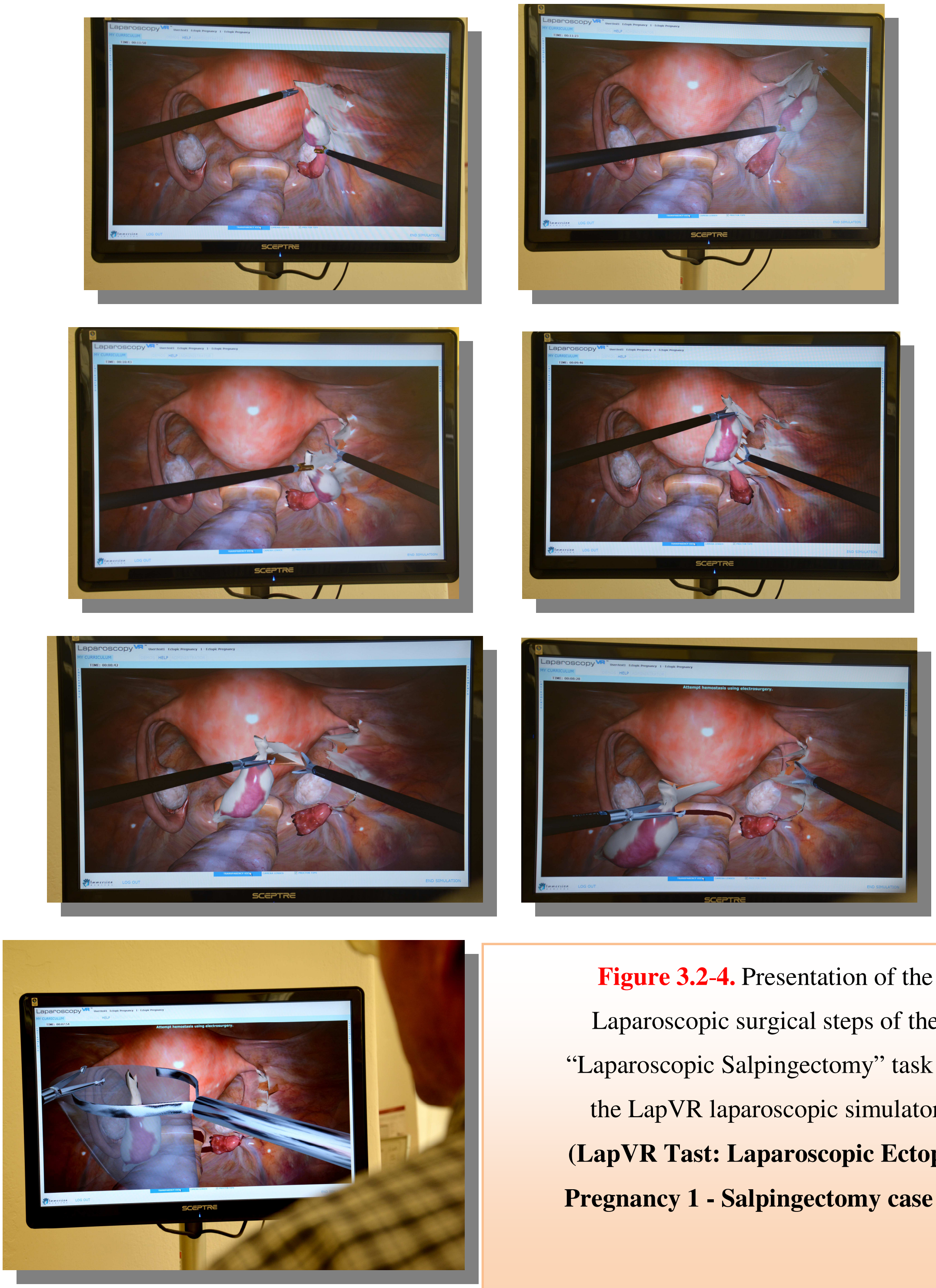


**Figure 3.2-4.** Presentation of the Laparoscopic surgical steps of the “Laparoscopic Salpingectomy” task on the LapVR laparoscopic simulator **(LapVR Tast: Laparoscopic Ectopic Pregnancy 1 - Salpingectomy case 2).**

The user identifies the infundibulo-ovarian ligament and coagulates using bipolar electrosurgery. Using scissors the user cuts through the middle of the desiccated area. Beginning at either end, the user starts the division of the mesosalpinx using bipolar electrosurgery, staying close to the fallopian tube and places tube with ectopic in specimen bag (**Figure 3.2-4**). The user assesses area for active bleeding and uses bipolar electrosurgery to stop any bleeding, cleans up operative area as needed by suctioning blood from cul-de-sac and the simulation ends.

The performance parameters are measured by the system at the end of the task. The following parameters were assessed:

- **The Time to Complete the Task** → … **(in minutes)**
- **The Time for Cautery Used** → … **(in seconds)**
- **The Time for Cautery Used in Air** → … **(in seconds)**
- **The Total Blood Loss** → … **(in cc)**
- **Percentage of Adhesions Ripped** →…. **(in %)**
- **Percentage of Adhesions Lysed** → … **(in %)**
- **The Left Path.Length** → … **(in meters)**
- **The Right Path Length** → … **(in meters)**

## 3.3. Pre-Assessment Tasks

All the participants of both groups (Group A and Group B) were evaluated for their pre-training laparoscopic ability by performing the laparoscopic salpingotomy and laparoscopic salpingectomy for ectopic pregnancy tasks in the LapVR laparoscopic simulator and measuring their performance parameters of each task by the LapVR laparoscopic simulator et the end of each task (**Table 3.2-2**).

**Table 3.2-2. LapVR simulator cases of the laparoscopic gynaecological procedures for the evaluation of the participants' laparoscopic surgery ability**

| | **Gynaecologic Procedures of the LapVR** | **Task Cases of the LapVR for the Research Study** |
|---|---|---|
| **Procedure 1** | Laparoscopic salpingotomy for ectopic pregnancy | Laparoscopic Ectopic Pregnancy 1 - Salpingotomy **case 1** |
| **Procedure 2** | Laparoscopic salpingectomy for ectopic pregnancy | Laparoscopic Ectopic Pregnancy 1 - Salpingectomy **case 2** |

## 3.4. Training in LapVR simulator versus box trainer

After finishing the pre-assessment task, the participants were randomly divided in two Groups (Group A and Group B) with 10 participants for each group.

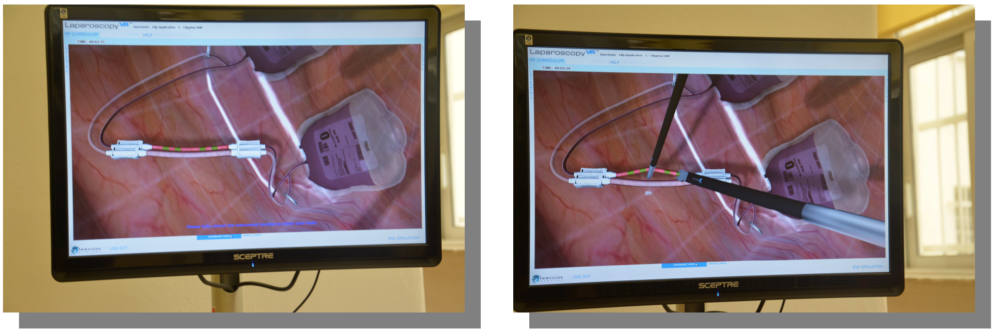
### 3.4.1. Group A (2 sessions, one and half hours per session)

The participants in Group A were trained on the laparoscopic VR equipment in two instructional sessions for one and half hours for each session. In a virtual reality environment, the "laparoscopic peg transfer", "laparoscopic clip a vessel" and "laparoscopic cutting" tasks were used.

Overview of three exercises in the ''basic laparoscopic curriculum'' of the LapVR simulator:

#### 3.4.1.1. Name of the exercise: "laparoscopic clipping of a vessel"

**Description of the exercise:** The trainer applies 4 clips at designated places and the vessel is completely grasped. This Module requires appropriate traction with one hand, while using the other to correctly place two clips to stop blood flow and then cut between the clips (**Figure 3.2-5**).



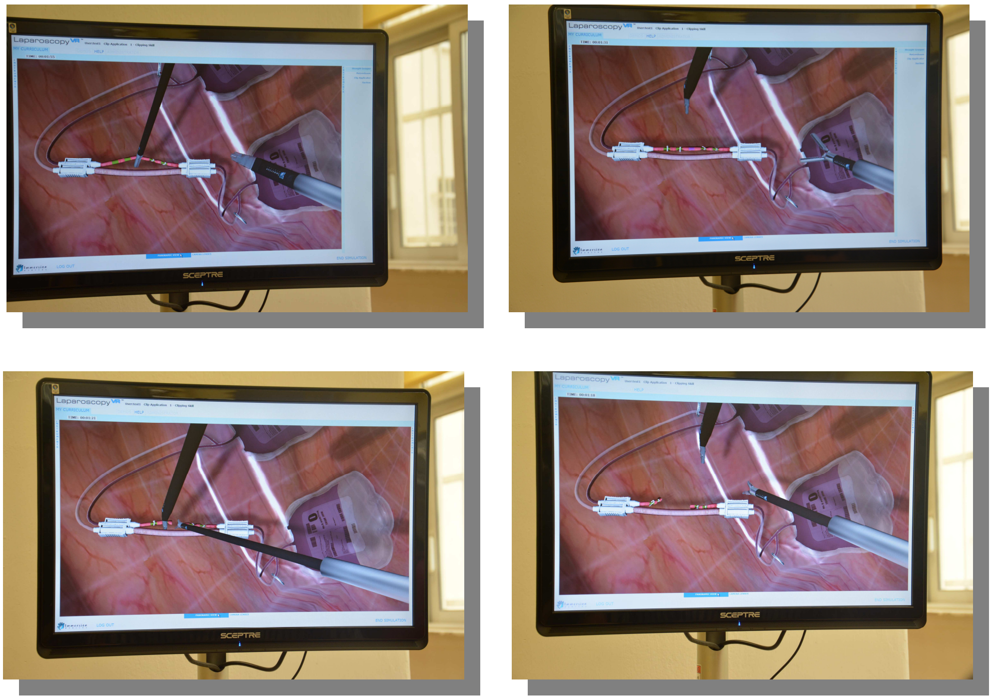


**Figure 3.2-5.** Presentation of the Laparoscopic steps of the exercise **"laparoscopic clip of a vessel"** on the LapVR laparoscopic simulator.

**Training goals:** Ambidextrous coordination and precision training.

Upon completion of this module the user obtains:

- improvement in dexterity in both the dominant and nondominant hands
- the concept of traction in clipping while recognizing when a vessel is appropriately placed between the jaws of the clip applicator before clipping
- increased precision and efficiency of motion
- clipping skills with both hands and in different planes and angles
- an ability to transfer the virtual reality experience of tool and camera navigation to the real life procedure
- end-of-practice feedback that can be used to identify strengths and areas needing improvement
- confidence in the use of laparoscopic surgical instruments before venturing into real patient scenarios

**Parameters:** The performance parameters are measured by the system at the end of the task.

**The following parameters were assessed for the "Laparoscopic clipping of the vessel" task on the Lap-VR simulator:**

- **Number of Clips applied in marked areas** → … **(in number)**
- **Number of Dropped Clips with the Left hand** → … **(in number)**
- **Number of Dropped Clips with the Right hand** → … **(in number)**
- **The Total Left hand path length** → … **(in meters)**
- **The Total Right hand path length** → … **(in meters)**
- **The Total Time to complete the task** → … **(in seconds)**

### 3.4.1.2. Name of the exercise: "laparoscopic peg transfer"

**Description of the exercise:** Peg transfer requires the trainer to pick up a series of four cylindrical pegs (6 mm wide, 1.7 cm long) from the floor of the cavity and place them into the correct holes of a pegboard (surface size 50 $cm^2$). Each time, a peg appears on either side of the pegboard (left or right). For the first two pegs the user has to use the grasper on that side to place the peg into a hole located also at the same side of the pegboard. For the next two pegs the user has to place them into a hole located at the other side of the pegboard, which required peg transfer between the graspers (i.e., a peg lying initially on the left side has to be picked up with the left grasper, transferred into the right grasper, and finally placed on a hole at the right side of the pegboard) (**Figure 3.2-6**).

**Training goals:** The goals for the Peg Transfer Module are to develop technical and dexterity skills needed for laparoscopic surgery while providing valuable feedback for self evaluation and improvement. The skill requires precise coordination of dominant and non-dominant hands, and sharpened depth perception and visual-spatial cognition within the simulated environment.

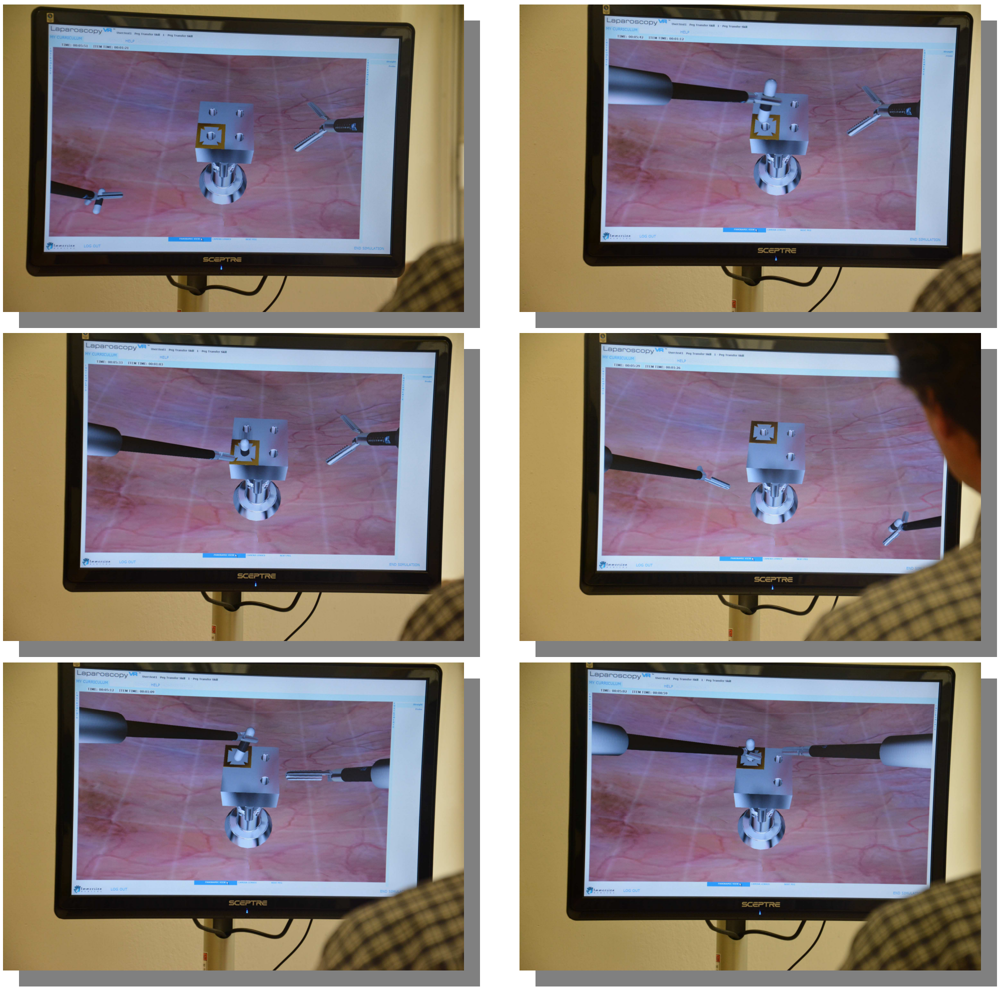


**Figure 3.2-6. Presentation of the Laparoscopic steps of the exercise "laparoscopic peg transfer" on the LapVR laparoscopic simulator.**

**Upon completion of this module the user obtains:**

- improvement in dexterity in both the dominant and nondominant hands
- improved eye-hand coordination within 3D virtual reality simulation by improving depth perception and visual-spatial cognition
- an increase in precision and efficiency of motion
- an ability to transfer the virtual reality experience of tool and camera navigation to the real life procedure
- end-of-practice feedback that can be used to identify areas of strength and areas needing improvement

- confidence in the use of laparoscopic surgical instruments before venturing into real patient scenarios

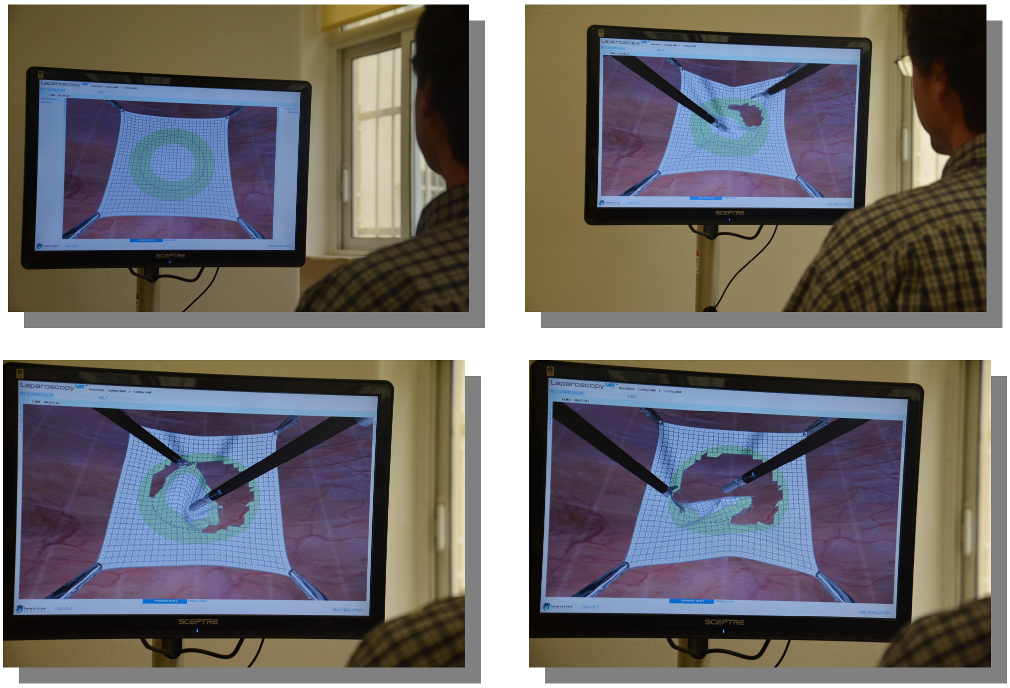
**Parameters:** The performance parameters are measured by the system at the end of the task.

**The following parameters were assessed for the "Laparoscopic peg transfer" task on the LapVR simulator:**

- **Number of dropped pegs with the Left Hand → … (in number)**
- **The Left hand total path length → … (in meters)**
- **Number of dropped pegs with Right Hand → … (in number)**
- **The Right hand total path length → … (in meters)**
- **The Total Time to complete task → … (in seconds)**

### 3.4.1.3. Name of the exercise: "Laparoscopic cutting"

**Description of the exercise:** The cutting task requires the user to accurately cut a section of gauze from a larger piece. Trainees have to cut along the perimeter of a circle (about 18 cm) within a boundary area that indicates the maximum allowable deviation (about 3 cm wide). It was important to maintain tension with the grasper and cut half of the cloth with the scissors, and then switch hands (**Figure 3.2-7**).



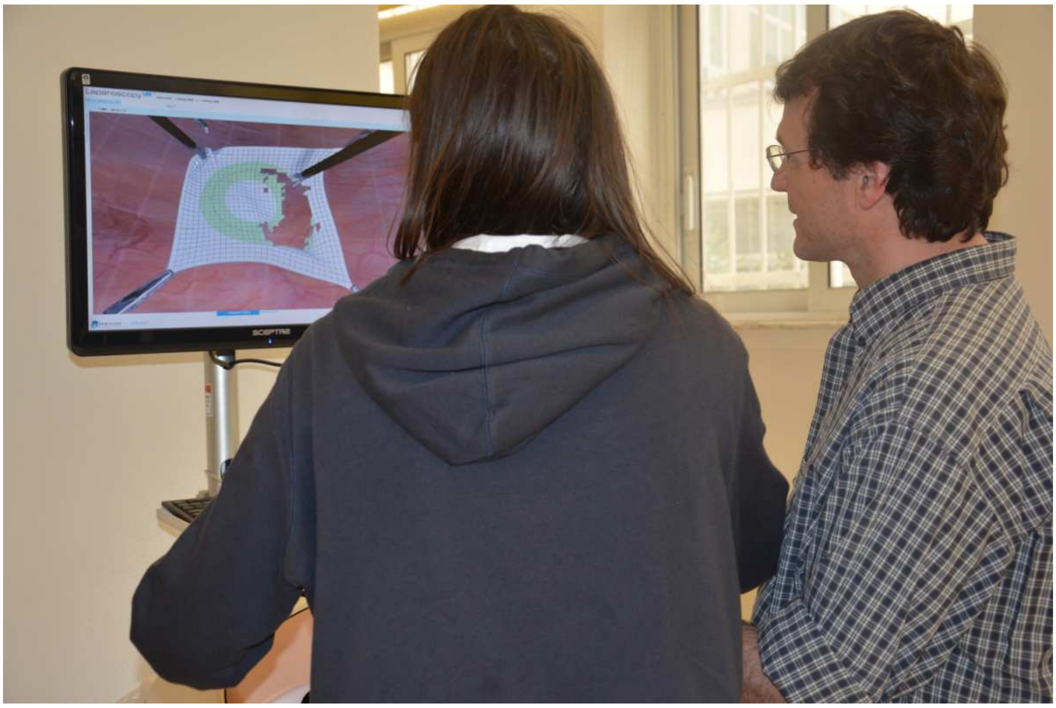


**Figure 3.2-7. Presentation of the Laparoscopic steps of the exercise "Laparoscopic cutting" on the LapVR laparoscopic simulator.**

**Training goals:** The goals of the Cutting task are to develop technical and dexterity skills needed for laparoscopic surgery such as improvement in dexterity in both the dominant and non-dominant hand, confidence in the use of laparoscopic surgical instruments, increased precision and efficiency of motion while cutting and the concept of traction in cutting, holding a tissue taut in order to improve cutting ease. Also, this task provides valuable feedback that can be used for self evaluation and improvement.

**Parameters:** The performance parameters are measured by the system at the end of the task.

**The following parameters were assessed for the "Laparoscopic cutting" task on the LapVR simulator:**

- **Average Grasping Tension → … (in Simulator Force Units)**
- **The Left hand path length → … (in meters)**
- **Number of unsuccessful cutting attempts with the left hand → … (in number)**
- **Percentage cutting out of boundary area with the Left Hand → … (in %)**
- **Percentage cutting out of boundary area with the Right Hand → … (in %)**
- **The Right hand path length → … (in meters)**
- **Number of unsuccessful cutting attempts with the right hand → … (in number)**
- **The Total Time to complete the task → … (in seconds)**

### 3.4.2. Group B (2 sessions, one and half hours per session)

The participants in Group B were practiced on the laparoscopic box-trainer (**Figure 8**) for one and half hours with training in the “laparoscopic ovarian cystectomy” and “laparoscopic salpingotomy” models.

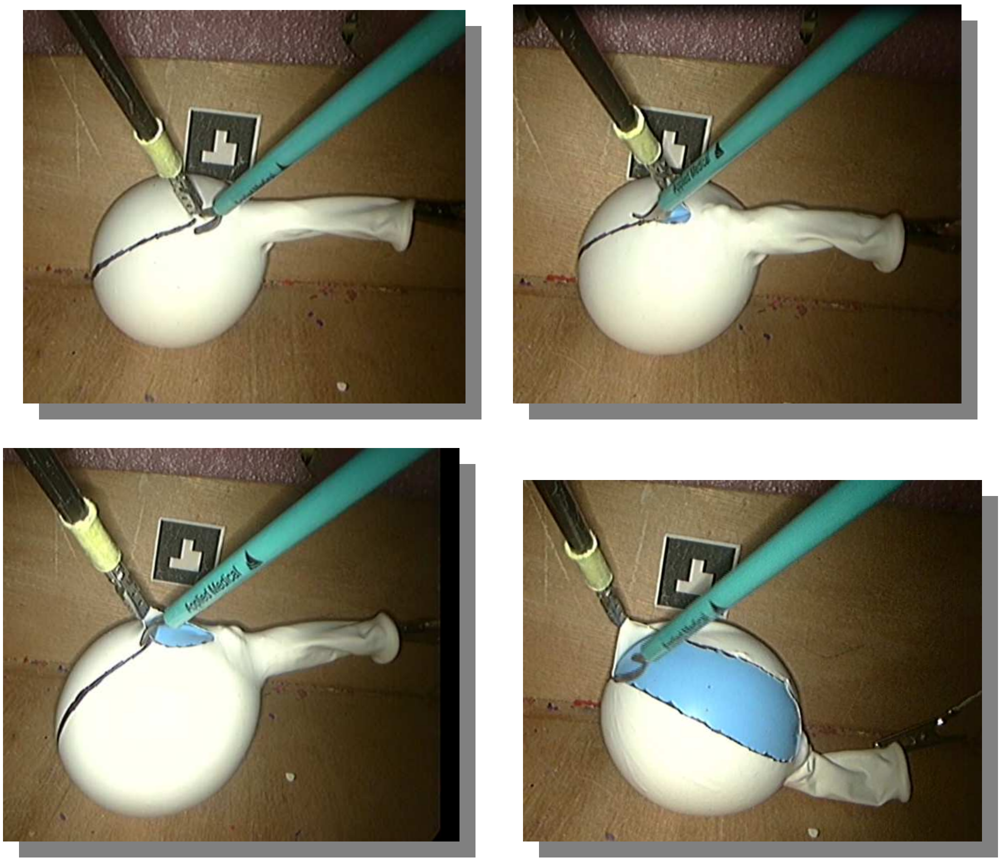
Overview of the two exercises on the laparoscopic video trainer:

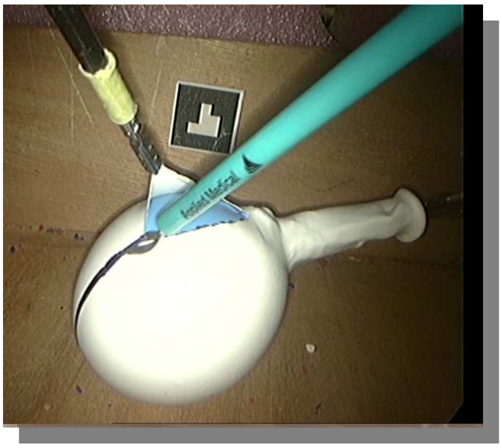
**Figure 3.2-8.** **Presentation of the laparoscopic box-trainer.**

### 3.4.2. 1. Name of the exercise: “Laparoscopic Ovarian Cystectomy”

**Description of the model:** The “laparoscopic ovarian cystectomy” model is composed of a medium-sized balloon filled with clay; this balloon is put inside a white-color balloon to serve as the ovarian cortex.  A 7-cm vertical black line on the white-color balloon is marked. This model is cost-effective to produce, reproducible, and simple enough to be produced for use by trainers in laboratory based surgical training centers.

**Activity of the exercise:** The participant has to cut the first balloon on the marked line with as much accuracy as possible avoiding the cutting of the second balloon, which represents the ovarian cyst (**Figure 3.2-9**).

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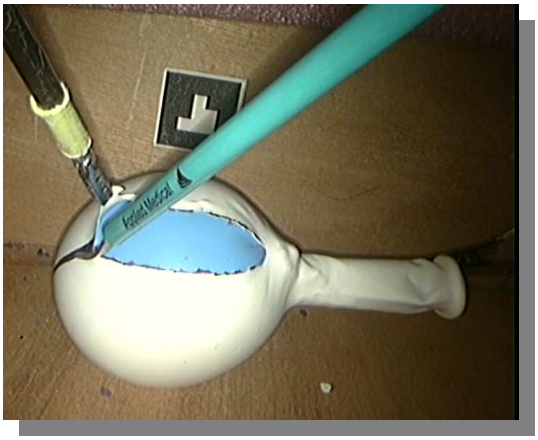
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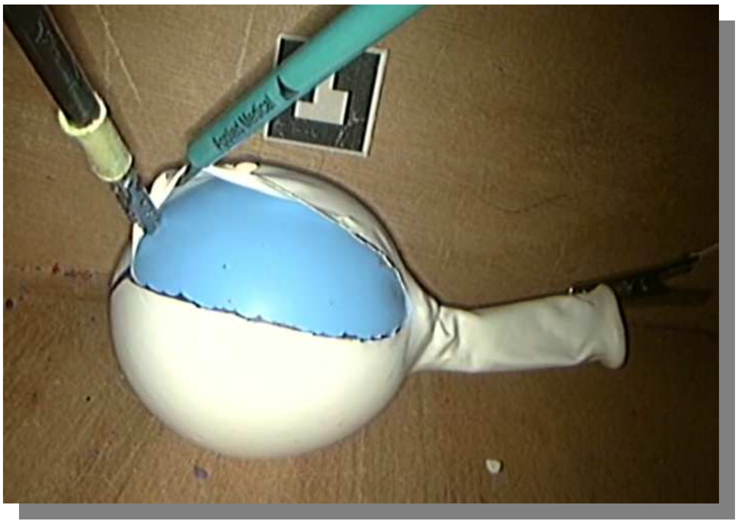
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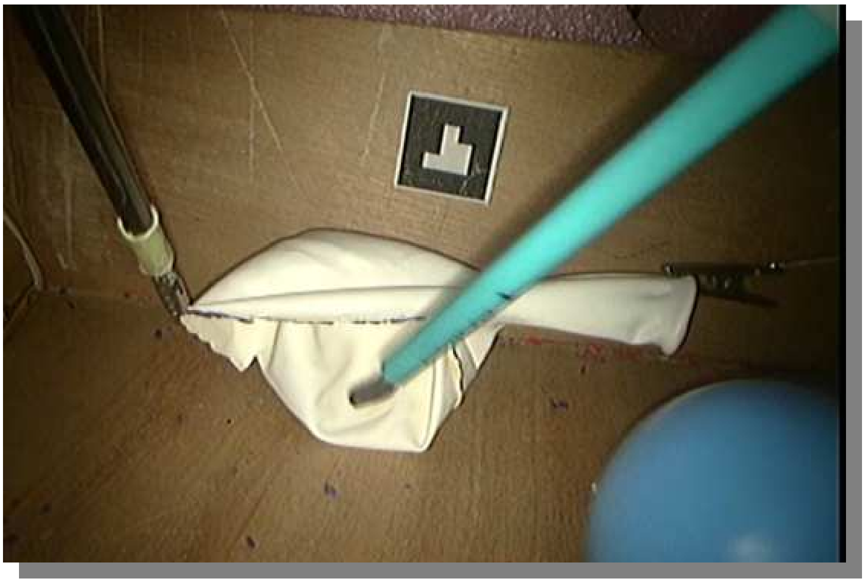


**Figure 3.2-9. Presentation of the Laparoscopic steps of the exercise "Laparoscopic Ovarian Cystectomy" on the laparoscopic box-trainer.**

**Skill Taught:** Coordination of both hands, sharp and blunt dissection and precision cuttings.

**Instruments:** 2 atraumatic laparoscopic graspers and 1 laparoscopic scissor.

**Parameters:** Task time, maximum allowed time, total path length (analysis from videos), rupture of the cyst (yes/no), maximum deviation from border line (mm), unsuccessful cuttings (analysis from videos), unsuccessful graspings (analysis from videos).

**The following parameters were assessed for the "Laparoscopic ovarian cystectomy" task on the Box-Trainer simulator:**

- **Total time to complete the task repetition → … (in minutes)**
- **Success for the Maximum Allowable Time (< 10 min) → … (yes = 1 or no = 2)**
- **Total path length for both hands* → … (in cm)**
- **Ballon Puncture → … (yes = 1 or no = 2)**
- **Minimal Damage in the "Cystic Wall" → … (yes = 1 or no = 2)**
- **Success for a 7-cm longitudinal incision on the ovarian cortex → … (yes = 1 or no = 2)**
- **Maximum deviation from the labeled – line → … (in millimeters)**

*As previously determined by Loucas et al 2012

### 3.4.2. 2. Name of the exercise: "Laparoscopic Salpingotomy"

**Description of the model:** The fallopian tube ectopic pregnancy model is composed of a 15-cm oblong balloon with a giant purple-bean inside it to serve as the trophoblastic tissue. The balloon is then sewn at both ends of the giant purple-bean using a usual thread. The one end of the oblong balloon is fixed to the lateral wall of the laparoscopic box trainer. The model is cost-effective to produce, reproducible, and simple enough to be produced for use by trainers in laparoscopic salpingostomy in laboratory based surgical training centers.

**Activity of the exercise:** The user has to make a longitudinal incision on the balloon and extract the bean (**Figure 3.2-10**).

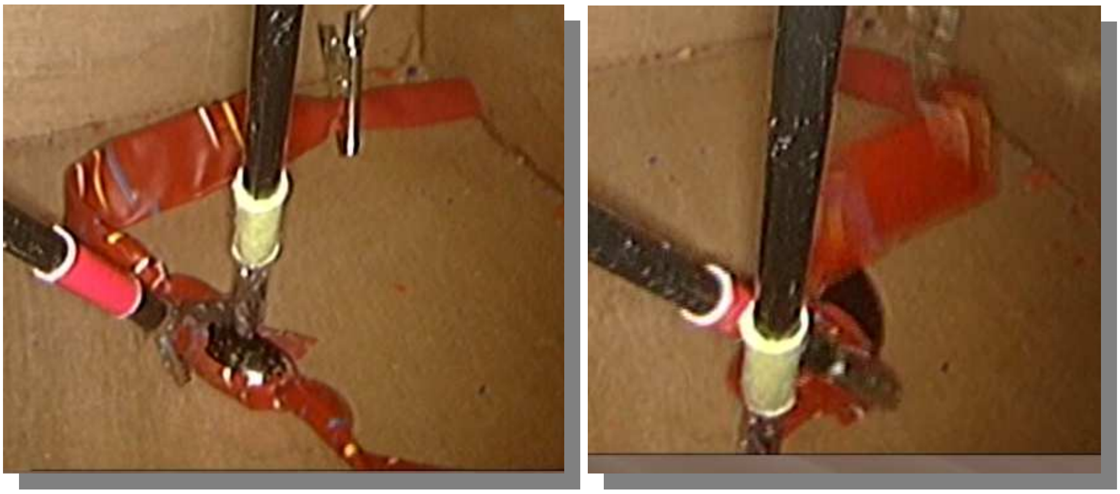


**Figure 3.2-10. Presentation of the Laparoscopic steps of the exercise "Laparoscopic Salpingotomy" on the laparoscopic box-trainer.**

**Instruments:** 2 atraumatic laparoscopic graspers and 1 laparoscopic scissor.

**Skill Taught:** Coordination of both hands and sharp and blunt dissections.

**Training goals:** Ambidextrous coordination.

**Parameters:** Task time, maximum allowed time, total path length (analysis from videos), unsuccessful cuttings (analysis from videos), unsuccessful graspings (analysis from videos), longitudinal versus transverse incision.

**The following parameters were assessed for the "Laparoscopic salpingotomy" task on the Box-Trainer simulator:**

- **Total time to complete the task repetition → … (in minutes)**
- **Completion of the task → … (yes or not)**
- **Success for the Maximum Allowable time (< 10 minutes) → … (yes = 1, no = 2)**
- **Total path length for both hands* → … (in cm)**

- **Success of longitudinal incision** → … **(yer or not)**

*As previously determined by Loucas et al 2012

## 3.5. Post-Assessment Tasks

At the completion of the training on the Lap-VRTM laparoscopic simulator and the laparoscopic box trainer (post-assessment tasks), all participants were evaluated for their post-training laparoscopic ability by performing the same tasks for laparoscopic salpingotomy and laparoscopic salpingectomy for ectopic pregnancy on the Lap-VRTM laparoscopic simulator as during the pre-assessment process. The performance parameters of each task were measured by the system of the Lap-VRTM laparoscopic simulator at the end of each task (**Table 3.2-2**).

## 3.6. Questionnaire from Group A participants

All participants from Group A and Group B filled in a questionnaire after performing the different skills on the LapVR laparoscopic simulator and the laparoscopic box trainer. In addition to the participant's demographics and laparoscopic experience, the questionnaire consisted of statements about the face validity of the LapVR laparoscopic simulator and the laparoscopic box trainer and the satisfaction of the participants from the laparoscopic experience they have gotten from the models using a Likert scale (1 to 5 ordinary answering scale from not realistic/useless to very realistic/very useful).

### 3.6.1. Post-training questionnaire for face validity of the salpingotomy for ectopic pregnancy in a 1 to 5 scale:

#### 3.6.1.1. Question

**Do you thing the training capacity is reached with this task?** (1 = not at all, 5 = yes for sure): …

#### 3.6.1.2. Question

**What do you think of …. ?**

**The choice of the task** (1 = very bad, 5 = very good): …

**The Software design** (1 = very bad, 5 = very good): …

**The realism of the surgical procedure** (1 = very bad, 5 = very good): …

**The realism of peritoneal cavity anatomy** (1 = very bad, 5 = very good): …

**The realism of camera simulation** (1 = very bad, 5 = very good): …

**The realism of instruments simulation** (1 = very bad, 5 = very good): …

**The realism of instruments freedom of movement** (1 = very bad, 5 = very good): …

**The depth perception** (1 = very bad, 5 = very good): …

**The realism of force feedback (haptics)** (1 = very bad, 5 = very good): …

**The realism of reaction to manipulation** (1 = very bad, 5 = very good): …

### 3.6.2. Post-training questionnaire for face validity of the salpingectomy for ectopic pregnancy in a 1 to 5 scale

#### 3.6.2.1. Question

**Do you thing the training capacity is reached with this task?** (1 = not at all, 5 = yes for sure): …

#### 3.6.2.2. Question

**What do you think of …. ?**

**The choice of the task** (1 = very bad, 5 = very good): …

**The Software design** (1 = very bad, 5 = very good): …

**The realism of the surgical procedure** (1 = very bad, 5 = very good): …

**The realism of peritoneal cavity anatomy** (1 = very bad, 5 = very good): …

**The realism of camera simulation** (1 = very bad, 5 = very good): …

**The realism of instruments simulation** (1 = very bad, 5 = very good): …

**The realism of instruments freedom of movement** (1 = very bad, 5 = very good): …

**The depth perception** (1 = very bad, 5 = very good): …

**The realism of force feedback (haptics)** (1 = very bad, 5 = very good): …

**The realism of reaction to manipulation** (1 = very bad, 5 = very good): …

### 3.6.3. Post-training questionnaire for face validity of the "clip a vessels" task in a 1 to 5 scale

#### 3.6.3.1. Question

**What do you think of the …?**

**The realism of the task** (1 = not realistic, 5 = Very realistic): …

**The appearance of the instruments** (1 = not realistic, 5 = Very realistic): …

**The movement of the instruments** (1 = not realistic, 5 = Very realistic): …

**Freedom of movements of the instruments** (1 = not realistic, 5 = Very realistic): …

**Depth perception** (1 = not realistic, 5 = Very realistic): …

**Interaction of the instruments with other objects** (1 = not realistic, 5 = Very realistic): …

**Adequacy of provided feedback** (1 = insufficient, 5 = sufficient): …

#### 3.6.3.2. Question

**What do you think of …?**

**The training capacity of the task** (1 = very bad, 5 = very good): …

**Eye-hand coordination** (1 = very bad, 5 = very good): …

**Depth perception** (1 = very bad, 5 = very good): …

**Instrument navigation in general** (1 = very bad, 5 = very good): …

**Training left and right hand separately** (1 = very bad, 5 = very good): …

**Training cooperation between left and right hand** (1 = very bad, 5 = very good): …

**Level of difficulty** (1 = easy, 5 = difficult): …

**Added value for training basic skills** (1 = not useful, 5 = very useful): ….

### 3.6.4. Post-training questionnaire for face validity of the "peg transfer" task in a 1 to 5 scale

#### 3.6.4.1. Question

**What do you think of the …?**

**The realism of the task** (1 = not realistic, 5 = Very realistic): …

**The appearance of the instruments** (1 = not realistic, 5 = Very realistic): …

**The movement of the instruments** (1 = not realistic, 5 = Very realistic): …

**Freedom of movements of the instruments** (1 = not realistic, 5 = Very realistic): …

**Depth perception** (1 = not realistic, 5 = Very realistic): …

**Interaction of the instruments with other objects** (1 = not realistic, 5 = Very realistic): …

**Adequacy of provided feedback** (1 = insufficient, 5 = sufficient): …

#### 3.6.4.2. Question

**What do you think of …?**

**The training capacity of the task** (1 = very bad, 5 = very good): …

**Eye-hand coordination** (1 = very bad, 5 = very good): …

**Depth perception** (1 = very bad, 5 = very good): …

**Instrument navigation in general** (1 = very bad, 5 = very good): …

**Training left and right hand separately** (1 = very bad, 5 = very good): …

**Training cooperation between left and right hand** (1 = very bad, 5 = very good): …

**Level of difficulty** (1 = easy, 5 = difficult): …

**Added value for training basic skills** (1 = not useful, 5 = very useful): …

### 3.6.5. Post-training questionnaire for face validity of the "cutting" task in a 1 to 5 scale

#### 3.6.5.1 Question

**What do you think of the …?**

**The realism of the task** (1 = not realistic, 5 = Very realistic): …

**The appearance of the instruments** (1 = not realistic, 5 = Very realistic): …

**The movement of the instruments** (1 = not realistic, 5 = Very realistic): …

**Freedom of movements of the instruments** (1 = not realistic, 5 = Very realistic): …

**Depth perception** (1 = not realistic, 5 = Very realistic): …

**Interaction of the instruments with other objects** (1 = not realistic, 5 = Very realistic): …

**Adequacy of provided feedback** (1 = insufficient, 5 = sufficient): …

#### 3.6.5.2 Question

**What do you think of …?**

**The training capacity of the task** (1 = very bad, 5= very good): …

**Eye-hand coordination** (1 = very bad, 5 =very good): …

**Depth perception** (1 = very bad, 5 = very good): …

**Instrument navigation in general** (1 = very bad, 5 = very good): …

**Training left and right hand separately** (1 = very bad, 5 = very good): …

**Training cooperation between left and right hand** (1 = very bad, 5 = very good): …

**Level of difficulty** (1 = easy, 5 = difficult): …

**Added value for training basic skills** (1 = not useful, 5 = very useful): …

### 3.6.6. Post-training questionnaire for face validity of the box trainer for salpingotomy in a 1 to 5 scale

#### 3.6.6.1. Question

**Do you thing the training goal is reached?** (1 = not at all, 5 = yes for sure): …

#### 3.6.6.3. Question

**What do you think of** …. ?

**The set-up of the task** (1 = very bad, 5 = very good): …

**The training capacity of task** (1 = very bad, 5 = very good): …

**Level of difficulty of the task** (1 = easy, 5 = difficult): …

**Added value for training basic skills** (1 = not useful, 5 = very useful): …

## 3.6.7. Post-training questionnaire for face validity of the box trainer for ovarian cystectomy in a 1 to 5 scale

### 3.6.7.1. Question

**Do you thing the training goal is reached?** (1 = not at all, 5 = yes for sure): …

### 3.6.7.1. Question

**What do you think of** …. ?

**The set-up of the task** (1 = very bad, 5 = very good): …

**The training capacity of task** (1 = very bad, 5 = very good): …

**Level of difficulty of the task** (1 = easy, 5 = difficult): …

**Added value for training basic skills** (1 = not useful, 5 = very useful): …

## 3.6.8. Post-training questionnaire of residents satisfaction with training modality

### 3.6.8.1. Question

**Did you enjoyed the training sessions as a whole?**

Yes

No

#### 3.6.8.2. Question

**Do you find fun to use the Box Trainer?**

Yes

No

#### 3.6.8.3. Question

**Do you fun to use the LapVR simulator?**

Yes

No

#### 3.6.8.4. Question

**Do you believe the operation tasks of the LapVR simulator can reduce complication rates?**

Yes

No

#### 3.6.8.5. Question

**Do you believe the training sessions were not long enough?**

Yes

No

#### 3.6.8.6. Question

**Do you feel more capable with laparoscopic salpingotomy at the end of the training session?**

Yes

No

#### 3.6.8.7. Question

**Do you feel more capable with laparoscopic salpingectomy at the end of the training session?**

Yes

No

#### 3.6.8.8. Question

**Do you believe the operation tasks of the LapVR simulator were fair evaluation of skills learned?**

Yes

No

#### 3.6.8.9. Question

**Do you believe this training modality was effective way to learn?**

Yes

No

#### 3.6.8.10. Question

**Do you believe this training modality must be acquired before one starts laparoscopic operating?**

Yes

No

### 3.6.8.11. Question

**Do you like to do more training on the same teaching modality?**

Yes

No

### 3.6.8.12. Question

**Do you believe it is important to practice entire procedures on virtual models?**

Yes

No

### 3.6.8.13. Question

**Do you believe the increment of skills during training must be monitored?**

Yes

No

### 3.6.8.14. Question

**Do you believe the operation tasks of the LapVR simulator give starting surgeons a sense of confidence?**

Yes

No

#### 3.6.8.15. Question

**Self-assessment of laparoscopic salpingotomy performance:**

Excellent

Good

Satisfactory

Not well at all

#### 3.6.8.16. Question

**Self-assessment of laparoscopic salpingectomy performance:**

Excellent

Good

Satisfactory

Not well at all

## 3.7. Questionnaire from Group B participants

### 3.7. 1. Post-training questionnaire for face validity of the salpingotomy for ectopic pregnancy in a 1 to 5 scale

#### 3.7.1.1. Question

**Do you thing the training capacity is reached with this task?** (1 = not at all, 5 = yes for sure): …

#### 3.7.1.2. Question

**What do you think of …. ?**

**The choice of the task** (1 = very bad, 5 = very good): …

**The Software design** (1 = very bad, 5 = very good): …

**The realism of the surgical procedure** (1 = very bad, 5 = very good): …

**The realism of peritoneal cavity anatomy** (1 = very bad, 5 = very good): …

**The realism of camera simulation** (1 = very bad, 5 = very good): …

**The realism of instruments simulation** (1 = very bad, 5 = very good): …

**The realism of instruments freedom of movement** (1 = very bad, 5 = very good): …

**The depth perception** (1 = very bad, 5 = very good): …

**The realism of force feedback (haptics)** (1 = very bad, 5 = very good): …

**The realism of reaction to manipulation** (1 = very bad, 5 = very good): …

### 3.7.2. Post-training questionnaire for face validity of the salpingectomy for ectopic pregnancy in a 1 to 5 scale

#### 3.7.2.1. Question

**Do you thing the training capacity is reached with this task?** (1 = not at all, 5 = yes for sure): …

#### 3.7.2.2. Question

**What do you think of …. ?**

**The choice of the task** (1 = very bad, 5 = very good): …

**The Software design** (1 = very bad, 5 = very good): …

**The realism of the surgical procedure** (1 = very bad, 5 = very good): …

**The realism of peritoneal cavity anatomy** (1 = very bad, 5 = very good): …

**The realism of camera simulation** (1 = very bad, 5 = very good): …

**The realism of instruments simulation** (1 = very bad, 5 = very good): …

**The realism of instruments freedom of movement** (1 = very bad, 5 = very good): …

**The depth perception** (1 = very bad, 5 = very good): …

**The realism of force feedback (haptics)** (1 = very bad, 5 = very good): …

**The realism of reaction to manipulation** (1 = very bad, 5 = very good): …

### 3.7.3. Post-training questionnaire for face validity of the box trainer for salpingotomy in a 1 to 5 scale

#### 3.7.3.1. Question

**Do you thing the training goal is reached?** (1 = not at all, 5 = yes for sure): …

#### 3.7.3.2. Question

**What do you think of** …. ?

**The set-up of the task** (1 = very bad, 5 = very good): …

**The training capacity of task** (1 = very bad, 5 = very good): …

**Level of difficulty of the task** (1 = easy, 5 = difficult): …

**Added value for training basic skills** (1 = not useful, 5 = very useful): …

### 3.7.4. Post-training questionnaire for face validity of the box trainer for ovarian cystectomy in a 1 to 5 scale

#### 3.7.4.1. Question

**Do you thing the training goal is reached?** (1 = not at all, 5 = yes for sure): …

#### 3.7.4.2. Question

**What do you think of** …. ?

**The set-up of the task** (1 = very bad, 5 = very good): …

**The training capacity of task** (1 = very bad, 5 = very good): …

**Level of difficulty of the task** (1 = easy, 5 = difficult): …

**Added value for training basic skills** (1 = not useful, 5 = very useful): …

### 3.7.5. Post-training questionnaire of residents satisfaction with training modality

#### 3.7.5.1. Question

**Did you enjoyed the training sessions as a whole?**

Yes

No

#### 3.7.5.2. Question

**Do you find fun to use the Box Trainer?**

Yes

No

#### 3.7.5.3. Question

**Do you fun to use the LapVR simulator?**

Yes

No

#### 3.7.5.4. Question

**Do you believe the operation tasks of the LapVR simulator can reduce complication rates?**

Yes

No

#### 3.7.5.5. Question

**Do you believe the training sessions were not long enough?**

Yes

No

#### 3.7.5.6. Question

**Do you feel more capable with laparoscopic salpingotomy at the end of the training session?**

Yes

No

#### 3.7.5.7. Question

**Do you feel more capable with laparoscopic salpingectomy at the end of the training session?**

Yes

No

#### 3.7.5.8. Question

**Do you believe the operation tasks of the LapVR simulator were fair evaluation of skills learned?**

Yes

No

#### 3.7.5.9. Question

**Do you believe this training modality was effective way to learn?**

Yes

No

#### 3.7.5.10. Question

**Do you believe this training modality must be acquired before one starts laparoscopic operating?**

Yes

No

#### 3.7.5.11. Question

**Do you like to do more training on the same teaching modality?**

Yes

No

#### 3.7.5.12. Question

**Do you believe it is important to practice entire procedures on virtual models?**

Yes

No

#### 3.7.5.13. Question

**Do you believe the increment of skills during training must be monitored?**

Yes

No

#### 3.7.5.14. Question

**Do you believe the operation tasks of the LapVR simulator give starting surgeons a sense of confidence?**

Yes

No

#### 3.7.5.15. Question

**Self-assessment of laparoscopic salpingotomy performance:**

Excellent

Good

Satisfactory

Not well at all

#### 3.7.5.16. Question

**Self-assessment of laparoscopic salpingectomy performance:**

Excellent

Good

Satisfactory

Not well at all

## 3.8. Statistical analysis

Statistical analysis was performed using SPSS 20.0 software for Windows (SPSS Inc., Chicago, IL, USA). Categorical variables were compared by $\chi^2$ test. Significance of differences in the measurements between two groups was determined by Mann–Whitney U test for non-parametrical data or one-way ANOVA analysis. Significant differences were calculated with the paired *t-test.* The correlation between cumulative scores from parameters obtained from the LapVR simulator was statistically assessed using the nonparametric Spearman's correlation analysis. In addition, the linear regression analysis was used to predict correlations between scores for parameters obtained from the LapVR simulator. Box whisker plots displaying the inter-quartile range, median, and mode were also constructed. Bar-graphs using the mean scores were constructed as well. Scatter plot visually displayed the findings between the scores from the analyzed parameters and the repetition numbers. A cluster analysis using the K-means algorithm was performed for defining any statistical significance between the time for completion the laparoscopic operations (laparoscopic salpingectomy for ectopic pregnancy or laparoscopic salpingotomy for ectopic pregnancy) versus economy of motions during the pre- and post-training tasks. A p-value of 0.05 or less was considered statistically significant.

## 3.3. Results

### 3.3.1. Demographics, experience and post-training residents' satisfaction with the training modality as a whole

A total of 20 participants have taken part in the research and completed the training modalities. All of the trainees were active residents in obstetrics and gynaecology. The **Tables 3.3-1 and 3.3-2** presents the demographic characteristics and experience data of the 20 participants who completed the training modalities according to the simulator type. All of the participants from both groups returned the questionnaire and completed the entire form. The median age of participants was 33.50 years (range = 30-41 years). Fifty-five (55%) of participants were male and forty-five (45%) were female. All of the trainees were right-handed (100%). Thirty-five percent were junior residents in Obstetrics and Gynaecology (years 1 and 2), 65% were senior residents; 40% of the trainees were in their fourth year of Obstetrics and Gynaecology training. In a rate of 40% and 30% the participants reported some previous video gaming and musical Instruments experience respectively; 55% reported as players of team sports. 80% of the participants had laparoscopic experience and 20% had previous Lap-VR simulator time.

Table 3.3-1: Demographic and Experience Information of the 20 Participants who Completed Training According to Simulator Type (LapVR simulator versus Laparoscopic Trainer-Box)

| Variables | Total | | LapVR Simulator (Group A) (n=10) | | Trainer-Box (Group B) (n=10) | | P-Values (t-test) |
|---|---|---|---|---|---|---|---|
| | Median | IQR | Median | IQR | Median | IQR | |
| Age Range | 33,5 | 3 | 34 | 3 | 33 | 3 | 0,517 |
| *Up to 30 yrs* | 30,5 | 1 | 30 | _ ** | 31 | _ ** | 0,423 |
| *Over 31 yrs* | 34 | 3 | 34 | 3 | 34 | 1 | 0,938 |
| | | | | | | | **P-Values (Fisher's Exact Test)** |
| Gender | | | | | | | 0,673 |
| *Male* | 55.0% | - | 60.0% | - | 50.0% | - | - |
| *Female* | 45.0% | - | 40.0% | - | 50.0% | - | - |
| | | | | | | | |
| Dexterity | | | | | | | |
| *Right* | 100.0% | - | 100.0% | - | 100.0% | - | - |
| *Left* | 0.0% | - | - | - | - | - | - |
| *Ambidextrous* | 0.0% | - | - | - | - | - | - |

**Table 3.3-2: …continuation of Table 1**

| Variables | Total | LapVR Simulator | Trainer-Box | P-Values (Fisher's Exact Test) |
|---|---|---|---|---|
| No Video Games Users (%) | 40.0% | 40.0% | 40.0% | 1 |
| No Musical Instruments Users (%) | 30.0% | 30.0% | 30.0% | 1 |
| No Players of Team Sports (5) | 55.0% | 60.0% | 50.0% | 1 |
| No Junior Residents (1-2 yrs) (%) | 35.0% | 20.0% | 50.0% | 0.350* |
| No Senior Residents (3-4 yrs) (%) | 65.0% | 80.0% | 50.0% | |
| No without previous laparoscopic training experience (%) | 80.0% | 70.0% | 90.0% | 0.582 |
| No in Lap-VR simulators previous laparoscopic training experience (%) | 20.0% | 30.0% | 10.0% | 0.582 |
| No in Live Animals previous laparoscopic training experience (%) | - | - | - | - |
| No in Human Cadavers previous laparoscopic training experience | 25.0% | 0.0% | 100.0% | - |
| No of Previous Laparoscopic Theatre Experience as Surgeon (%) | 0.0% | 0.0% | 0.0% | - |
| No of Previous Laparoscopic Theatre Experience as Assistant (%) | 85.0% | 70.0% | 100.0% | 0.211 |

Data displayed as number (%) or median (range); (tests significance p<0.05)

*For residency overall, not broken down

**Results not valid, due to small sample size

Figure 3.3-1: % of participants’ Age and Gender, by Group

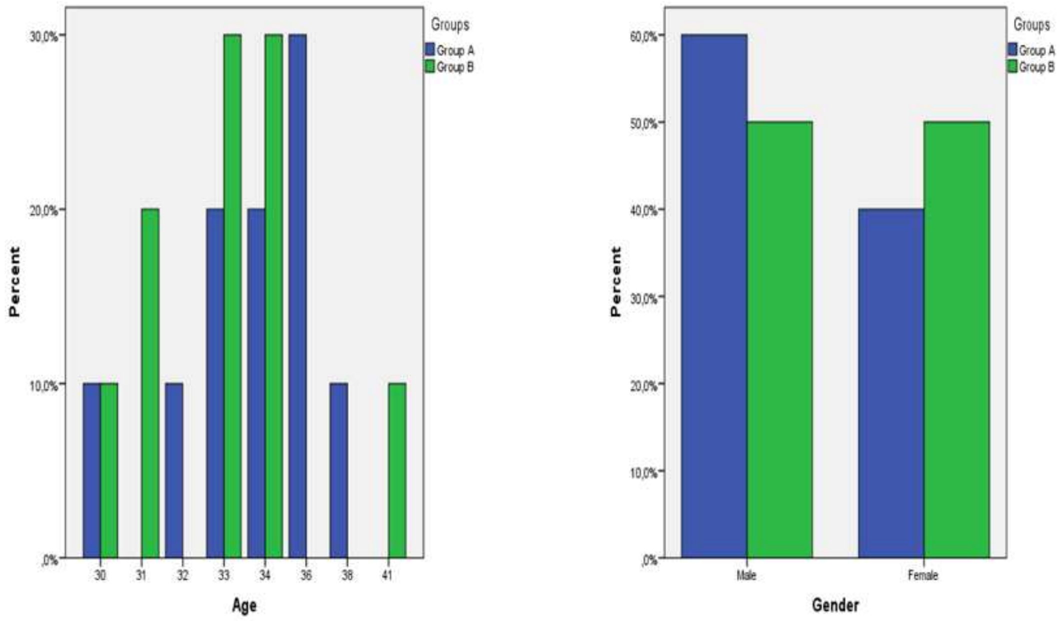


**Figure 3.3-2:** % of participants that play video games and musical instruments, by group

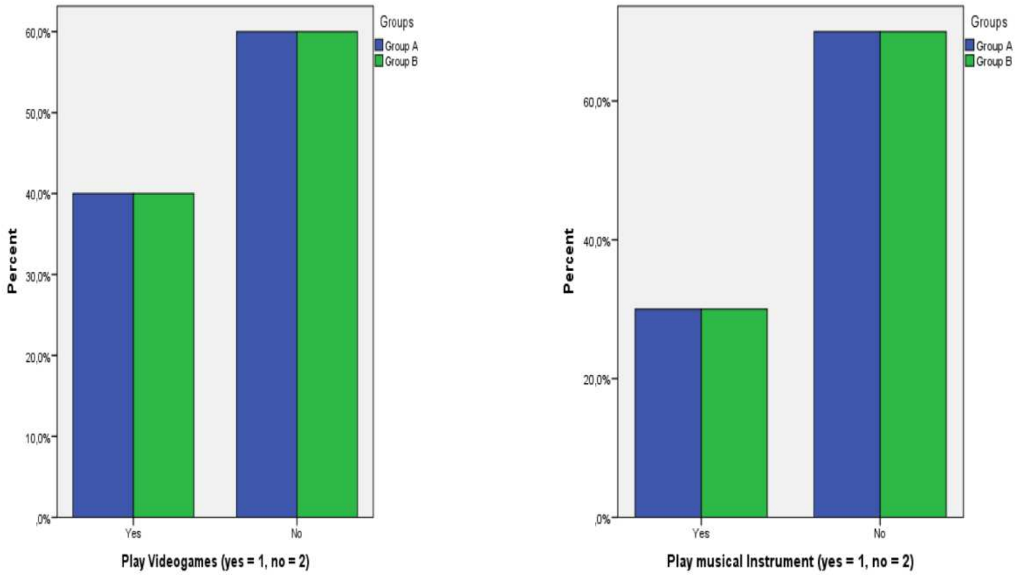
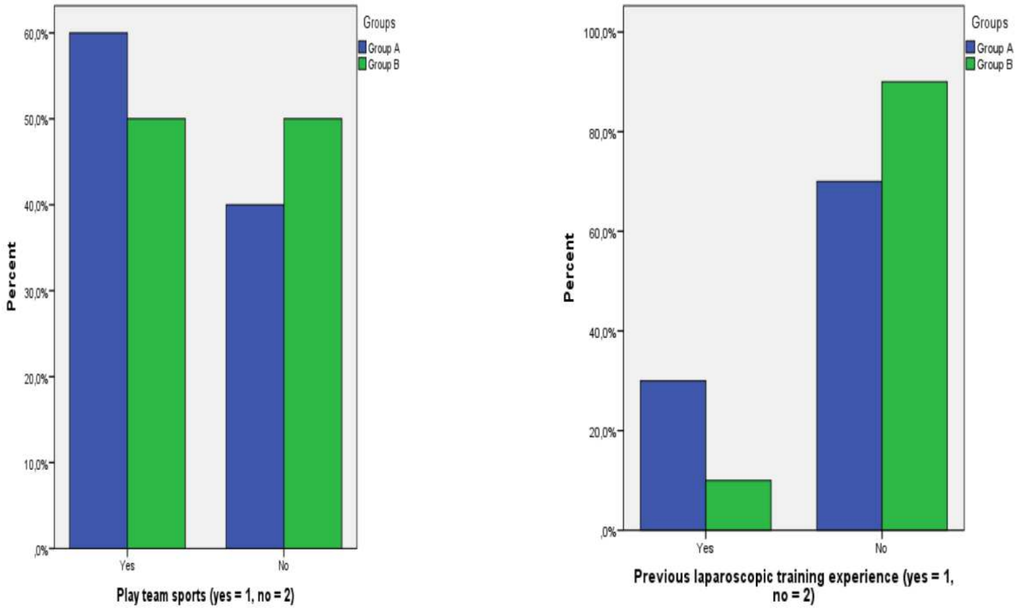


**Figure 3.3-3:** Percentage of Participants that Play Team Sports (in %) and Percentage of Participants with Previous Laparoscopic Training Experiences (in %), by group



Most of the residents enjoyed the training modality and the experience they have taken (see **Table 3.3-3**). In particular, 100 % enjoyed the training sessions as a whole and 95% found fun to use the LapVR simulator. Between the participants in Group-B, 100% found fun to use the laparoscopic Box-Trainer. 100% believed that the operation tasks of the LapVR simulator can reduce complication rates. Also, 90% believed that the operation tasks of the LapVR simulator give starting surgeons a sense of confidence. In addition, 90% and 70% felt more capable with laparoscopic salpingotomy and salpingectomy at the end of the training session respectively. 90% believed that the operation tasks of the LapVR simulator were fair evaluation of skills learned and 90% believed that this training modality was effective way to learn. A rate of 100% believed this training modality must be acquired before one starts laparoscopic operating. 100% wanted to make more training on the same teaching modality and 55% believed that the training sessions were not long enough. 90% believed that it is important to practice entire procedures on virtual models, while 90% believed that the increment of skills during training must be monitored. No statistical significant differences between both groups were found. In the self-assessment of the laparoscopic salpingotomy and laparoscopic salpingectomy performance the majority considered their performance to be satisfactory or good (see **Table 3.3-3**). No statistical significant differences between the two groups were found.

**Table 3.3-3:** Post - training questionnaire about the Participants’ Satisfaction with the training modality as a whole according to the Simulator Type (LapVR simulator versus laparoscopic Trainer-Box)

| **Variables** | **Total** | **LapVR Simulator (n=10)** | **Trainer - Box (n=10)** | **P-Values (Fisher's Exact Test)** |
|---|---|---|---|---|
| Enjoyed the Training Sessions as a whole (%) | 100.0% | 100.0% | 100.0% | - |
| Believed the operation tasks of the LapVR simulator can reduce complication rates (%) | 100.0% | 100.0% | 100.0% | - |
| Believed the training sessions were not long enough (%) | 55.0% | 60.0% | 50.0% | 1 |
| Felt more capable with laparoscopic salpigotomy at the end of the training sessions (%) | 90.0% | 90.0% | 90.0% | 1 |
| Felt more capable with laparoscopic salpingectomy at the end of the training sessions (%) | 70.0% | 70.0% | 70.0% | 1 |
| Believed the operation tasks of the Lap-VR simulator were fair evaluation of skills learned (%) | 90.0% | 90.0% | 90.0% | 1 |
| Believed the training modality was effective way to learn (%) | 90.0% | 90.0% | 90.0% | 1 |
| Believed the training modality must be acquired before one starts laparoscopic operating (%) | 100.0% | 100.0% | 100.0% | - |
| Would like to do more training on the same teaching modality (%) | 100.0% | 100.0% | 100.0% | - |
| Believed as important to practice entire procedure on LapVR simulator (%) | 90.0% | 90.0% | 90.0% | 1 |
| Believed the increment of skills during training must be monitored (%) | 90.0% | 90.0% | 90.0% | 1 |
| Believed the operation tasks of the LapVR simulator give starting surgeons a sense of confidence (%) | 90.0% | 90.0% | 90.0% | 1 |
| **Self-assessment of Laparoscopic Salpingotomy Performance (%)** | | | | **0.147 (Chi - Square P-Value)** |
| *Excellent* | 30.0% | 50.0% | 10.0% | |
| *Good* | 30.0% | 20.0% | 40.0% | |
| *Satisfactory* | 40.0% | 30.0% | 50.0% | |
| *Not well et al* | - | - | - | |
| **Self-assessment of Laparoscopic Salpingectomy Performance (%)** | | | | **0.392 (Chi - Square P-Value)** |
| *Excellent* | 10.0% | 0.0% | 20.0% | |
| *Good* | 30.0% | 30.0% | 30.0% | |
| *Satisfactory* | 40.0% | 40.0% | 40.0% | |
| *Not well et al* | 20.0% | 30.0% | 10.0% | |

### 3.3.2. Analysis for the Laparoscopic Salpingotomy task on the LapVR simulator

Most of the residents found as very good the choice of the task (70%). The **Tables 3.3-4a and 3.3-4b** depicts the face validity for the laparoscopic salpingotomy on the LapVR simulator and gives the mean and standard deviation of the scores obtained from the feedback questionnaire between the participants from the Group A and Group B respectively. The Mann–Whitney U test, comparing the difference of opinion between participants in group A and group B, did not show any significance for all of the questions. This suggests that there was no difference of opinion between the two groups on all the questions. The lowest mean score received for all of the questions was 2.36 for the depth perception, addressing the problem of the Lap-VRT simulator in this aspect. 70% of the participants rated depth perception 3 and below on the 5-point Likert while 30% rated this feature a score of 4-5 (Rather good and Very good). Low was the mean score received for the realism of force feedback (haptics) (3.60). The highest mean received for all of the questions was 4.40 for the realism of camera simulation. This implies that the LapVR simulator is satisfactory in all the aspects of simulation quality that were examined. Strong agreement among the subjects was evident from the low standard deviation. The maximum standard deviation was 1.231, which was reported on the realism of force feedback (haptics).

**Table 3.3-4a:** Face validity: Descriptive statistics obtained from the feedback questionnaire

| Questionnaire (Training Realism) | Total | | Group A | | Group B | | p-values of Mann - Whitney U Test |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Software Design | 4.25 | 0.786 | 4.40 | 0.516 | 4.10 | 0.994 | 0.684 |
| Realism of the Surgical Procedure | 3.95 | 0.887 | 4.00 | 0.667 | 3.90 | 1.101 | 0.971 |
| Realism of Peritoneal Cavity Anatomy | 4.20 | 0.834 | 4.00 | 0.943 | 4.40 | 0.699 | 0.393 |
| Realism of Camera Simulation | 4.40 | 0.598 | 4.40 | 0.699 | 4.40 | 0.516 | 0.912 |
| Realism of Instruments Simulation | 4.25 | 0.910 | 4.10 | 0.994 | 4.40 | 0.843 | 0.529 |
| Realism of Instruments Freedom/Movements | 4.15 | 0.745 | 4.20 | 0.789 | 4.10 | 0.738 | 0.796 |
| Realism of force feedback (haptics) | 3.60 | 1.231 | 3.50 | 1.354 | 3.70 | 1.160 | 0.739 |
| Realism of reaction to manipulation | 4.05 | 0.887 | 3.90 | 0.876 | 4.20 | 0.919 | 0.393 |

**Table 3.3-4b:** Face validity: Descriptive statistics obtained from the feedback questionnaire in terms of Depth Perception

| Questionnaire (Training Capacities) | Total | | *Group A* | | Group B | | p-values of Mann - Whitney U Test |
|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | ***Mean*** | ***SD*** | **Mean** | **SD** | |
| ***The Depth Perception*** | | | | | | | |
| score 4–5 | 4.33 | 0.516 | 4.25 | 0.500 | 4.5 | 0.707 | 0.800 |
| score 1–3 | 2.36 | 0.745 | 2.33 | 0.816 | 2.38 | 0.744 | 0.950 |

The **Table 3.3-5** depicts the content validity for the laparoscopic salpingotomy on the Lap-VRT simulator. The question if the training capacity was reached with this task and the procedure was functioning was rated above a score of 3 on the 5-point Likert scale with 100% of the participants to score 4–5 on the 5-point Likert scale. The Mann–Whitney U test, comparing the difference of opinion between participants in group A and group B, did not show any significance for this question suggesting that there was no difference of opinion between the two groups.

**Table 3.3-5:** Content Validity: descriptive statistics obtained from the feedback questionnaire

| Questionnaire (Training Capacities) | Total | | Group A | | Group B | | p-values of Mann - Whitney U Test |
|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | |
| **Training Capacity Reached (Procedural Functioning)** | | | | | | | |
| *score 4–5* | 4.4 | 0.503 | 4.3 | 0.483 | 4.5 | 0.527 | 0.481 |
| *score 1–3* | - | - | - | - | - | - | - |

All the participants from both groups completed the operation (laparoscopic salpingotomy) during the pre-training task. The comparison of the results of the pre-training tests between the Group-A and the Group-B are given in **Table 3.3-6**. There were no significant differences between the participants in Group A and Group B.

**Table 3.3-6:** Comparison of the pre-training results between the Group-A and the Group-B

| Parameters | Group A |  | Group B |  | One Way ANOVA *p-Values* | p-values of Mann - Whitney U Test |
|---|---|---|---|---|---|---|
|  | Mean | SD | Mean | SD |  |  |
| **Percentage of Participants who Completed the Operation (%)** | **100%** | **-** | **100%** | **-** | **-** | **-** |
| Time for Task Completion (min) | 4.20 | 2.35 | 4.60 | 1.90 | 0.680 | 0.631 |
| Time for Cautery Used (sec) | 30.44 | 38.51 | 28.89 | 19.60 | 0.911 | 0.315 |
| Time for Cautery Used in Air (sec) | 23.29 | 35.40 | 19.83 | 19.27 | 0.789 | 0.579 |
| Total Blood Loss (cc) | 8.24 | 20.64 | 20.17 | 26.09 | 0.272 | 0.190 |
| Incision Length (cm) | 2.42 | 0.46 | 2.33 | 0.52 | 0.670 | 0.971 |
| Left Path Length (m) | 3.09 | 1.21 | 2.92 | 0.99 | 0.741 | 0.971 |
| Right Path Length (m) | 3.51 | 1.82 | 3.37 | 1.27 | 0.845 | 0.971 |
| Total Path Length (m) | 6.60 | 2.85 | 6.29 | 2.13 | 0.790 | 1.000 |

*t-test and ANOVA results are identical.

All the participants from both groups completed the operation (laparoscopic salpingotomy) during the post-training task. The comparison of the results of the post-training tests between the Group-A and the Group-B are given in **Table 3.3-7**. Laparoscopic salpingotomy was completed quite faster by the participants in the group A than by participants in Group B. Participants in Group A used quite less path length than participants in Group-B with both right and left hand. There were no significant differences between participants in Group A and Groups B with all the analysis parameters, although a total blood loss showed a trend in favor of participants in Group A.

**Table 3.3-7:** Comparison of the post-training results between the Group-A and the Group-B

| Parameters | Group A |  | Group B |  | One Way ANOVA p-values | p-values of Mann - Whitney U Test |
|---|---|---|---|---|---|---|
|  | Mean | SD | Mean | SD |  |  |
| **Percentage of Participants who Completed the Operation (%)** | **100%** | **-** | **100%** | **-** | **-** | **-** |
| Time for Task Completion (min) | 3.70 | 2.00 | 4.20 | 2.74 | 0.647 | 0.971 |
| Time for Cautery Used (sec) | 32.17 | 33.61 | 50.24 | 63’89 | 0.439 | 0.579 |
| Time for Cautery Used in Air (sec) | 15.52 | 16.56 | 36.35 | 57.14 | 0.283 | 0.353 |
| Total Blood Loss (cc) | 31.06 | 69.40 | 132.45 | 321.82 | 0.343 | 0.529 |
| Incision Length (cm) | 2.26 | 0.67 | 2.68 | 0.98 | 0.281 | 0.315 |
| Left Path Length (m) | 2.85 | 2.84 | 3.50 | 2.47 | 0.593 | 0.218 |
| Right Path Length (m) | 3.72 | 2.67 | 4.14 | 2.50 | 0.722 | 0.393 |
| Total Path Length (m) | 6.57 | 5.32 | 7.64 | 4.89 | 0.647 | 0.353 |

*t-test and ANOVA results are identical.

The comparison of the results of the pre-training test compared to the post-training test for each group is given in **Table 3.3-8**. ANOVA analysis was performed between the groups. It did not demonstrate significant changes between pre- and post-training scores for the mean for all the analysis parameters.

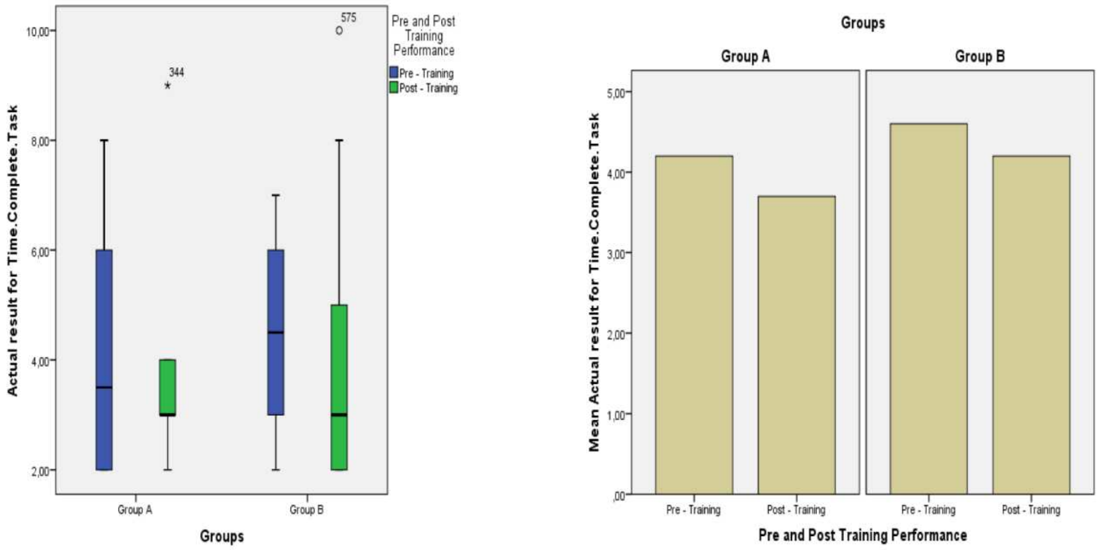
**Table 3.3-8:** Difference in the pre-training as compared to the post-training test results for the Group A and the Group B

| **Parameters** | **Pre - training test** | | **Post - training test** | | **One Way ANOVA** | **p-values of Mann - Whitney U Test** |
|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | | |
| **Group A** | | | | | | |
| ***Percentage of Participants who Completed the Operation (%)*** | **100%** | - | **100%** | - | - | - |
| Time for Task Completion (min) | 4.20 | 2.35 | 3.70 | 2.00 | 0.615 | 0.853 |
| Time for Cautery Used (sec) | 30.44 | 38.51 | 32.17 | 33.61 | 0.916 | 0.912 |
| Time for Cautery Used in Air (sec) | 23.29 | 35.40 | 15.52 | 16.56 | 0.537 | 0.739 |
| Total Blood Loss (cc) | 8.24 | 20.64 | 31.06 | 69.40 | 0.332 | 0.684 |
| Incision Length (cm) | 2.42 | 0.46 | 2.26 | 0.67 | 0.532 | 0.353 |
| Left Path Length (m) | 3.09 | 1.21 | 2.85 | 2.84 | 0.814 | 0.190 |
| Right Path Length (m) | 3.51 | 1.82 | 3.72 | 2.67 | 0.838 | 0.684 |
| Total Path Length (Left & Right) (m) | 6.60 | 2.85 | 6.57 | 5.32 | 0.991 | 0.315 |
| **Group B** | | | | | | |
| ***Percentage of Participants who Completed the Operation (%)*** | **100%** | - | **100%** | - | - | - |
| Time for Task Completion (min) | 4.60 | 1.90 | 4.20 | 2.74 | 0.709 | 0.481 |
| Time for Cautery Used (sec) | 28.89 | 19.60 | 50.24 | 63.89 | 0.326 | 0.739 |
| Time for Cautery Used in Air (sec) | 19.83 | 19.27 | 36.35 | 57.14 | 0.398 | 0.853 |
| Total Blood Loss (cc) | 20.17 | 26.09 | 132.45 | 321.82 | 0.286 | 0.684 |
| Incision Length (cm) | 2.33 | 0.52 | 2.68 | 0.98 | 0.333 | 0.631 |
| Left Path Length (m) | 2.92 | 0.99 | 3.50 | 2.47 | 0.499 | 0.971 |
| Right Path Length (m) | 3.37 | 1.27 | 4.14 | 2.50 | 0.398 | 0.739 |
| Total Path Length (Left & Right) (m) | 6.29 | 2.13 | 7.64 | 4.89 | 0.434 | 0.971 |

*t-test and ANOVA results are identical.

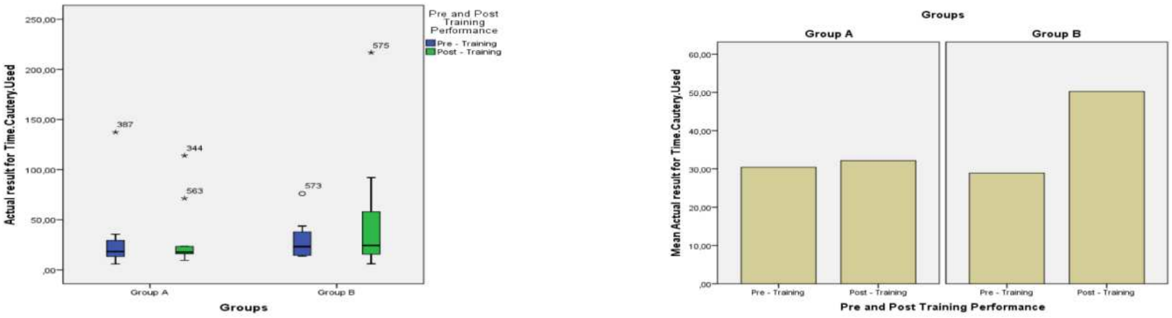
- For Group A, the mean time for completing the task has decreased, so has the time for cautery used in air, the incision length, the left path length and the total path length. On the other hand, the other analysis analytical parameters increased on the post-training performance of the task.
- For Group B, aside of the mean time to complete the task, all the other analysis parameters have increased on post-training performance.

**Figure 3.3-4:** Box plot and bar-graph comparing the Total Time (in minutes) taken for participants in Group-A and participants in Group-B between pre-test and post-test assessment



In both cases, **the median of the time to complete the task has reduced during the post-training as compared to the pre-training**. The outliers in the boxplots are shown in circles (labeled by the subject's number).

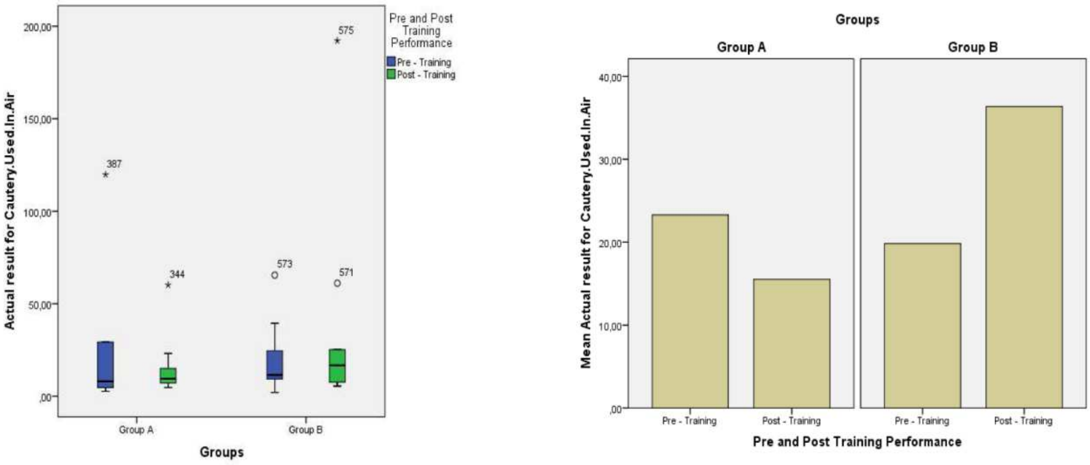
**Figure 3.3-5:** Box plot and bar-graph comparing the Time for Cautery Used (in seconds) for participants in Group-A and participants in Group-B between pre-test and post-test assessment



In both cases, the median of the Time of Cautery Used has not deviated largely during post-training. Specifically, **for group B at post-training, the shape of**

**the boxplot indicates that observations are unevenly spread above the median, therefore dragging mean upwards**.

**Figure 3.3-6:** Box plot and bar-graph comparing the Time for Cautery Used in Air (in seconds) for participants in Group-A and participants in Group-B between pre-test and post-test assessment.



**The median for group B at the post-training session has been shifted upward**, though most observations appear to distribute evenly up and below that figure, except for the two outliers.

**Figure 3.3-7:** Box plot and bar-graph comparing the Total Blood Loss (in cc) for participants in Group-A and participants in Group-B between pre-test and post-test assessment

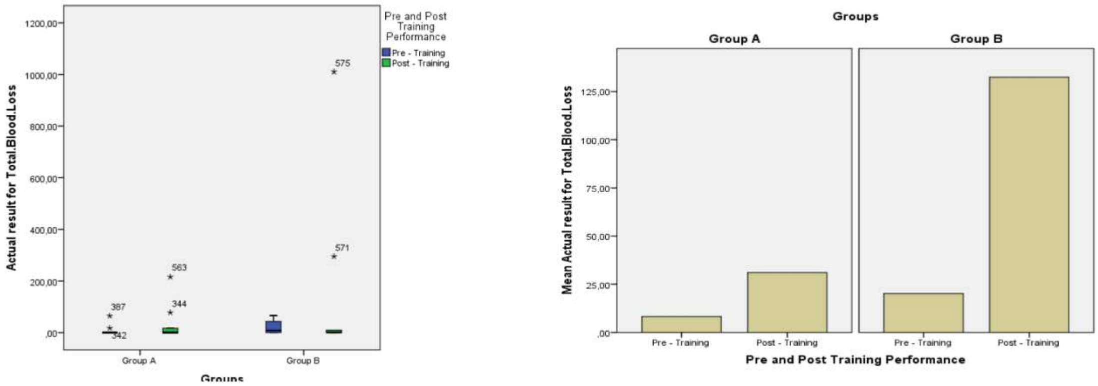
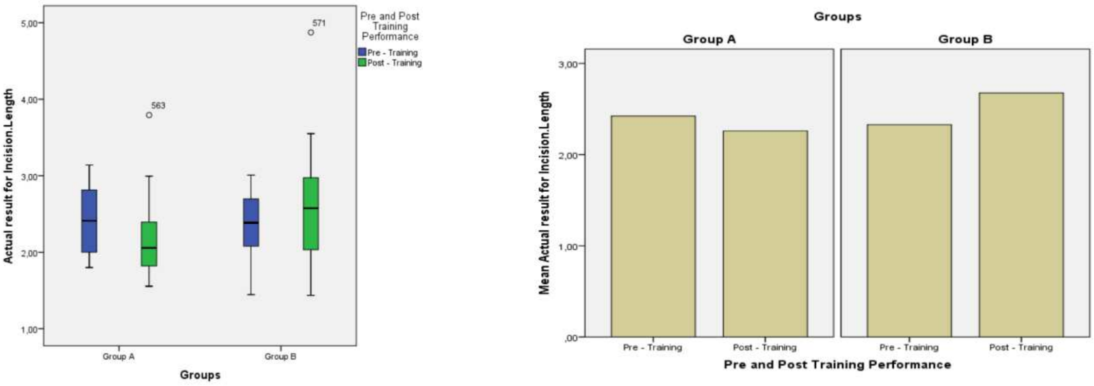


**Figure 3.3-8:** Box plot and bar-graph comparing the Incision Length (in cm) for participants in Group-A and participants in Group-B between pre-test and post-test assessment



Regarding incision length, the median exhibits **opposite behavior between the two groups and between the pre- and post-training performance**. **For group A, the median decreases in post-training while for group B, it increases**.

**Figure 3.3-9:** Box plot and bar-graph comparing the Left Path Length (in meters) for participants in Group-A and participants in Group-B between pre-test and post-test assessment

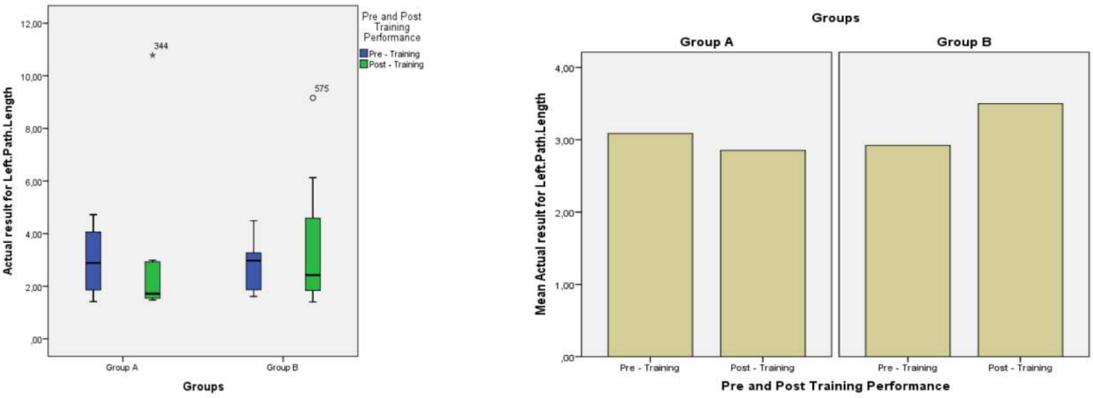


**Figure 3.3-10:** Boxplot and bar-graph comparing the Right Path Length (in meters) for participants in Group-A and participants in Group-B between pre-test and post-test assessment

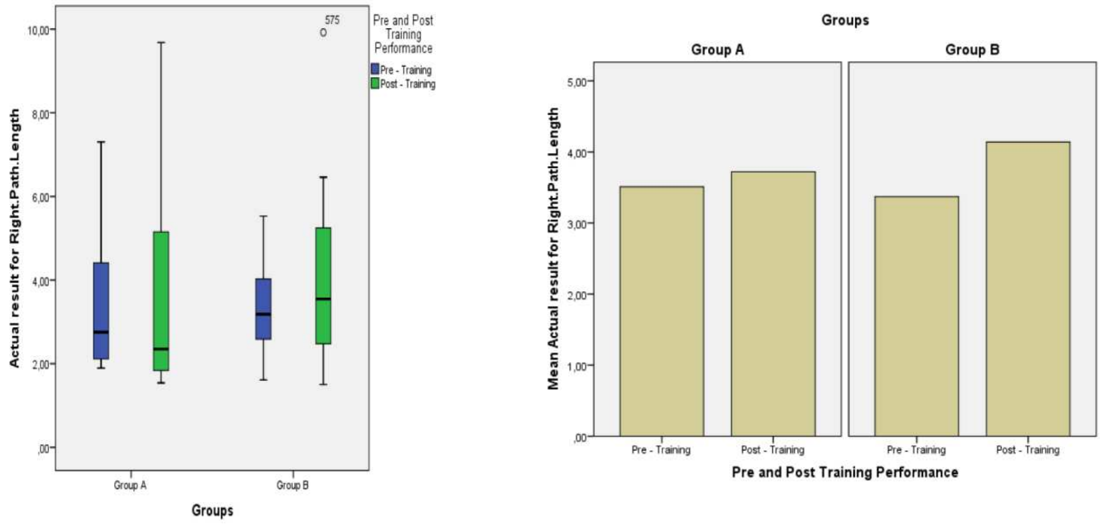
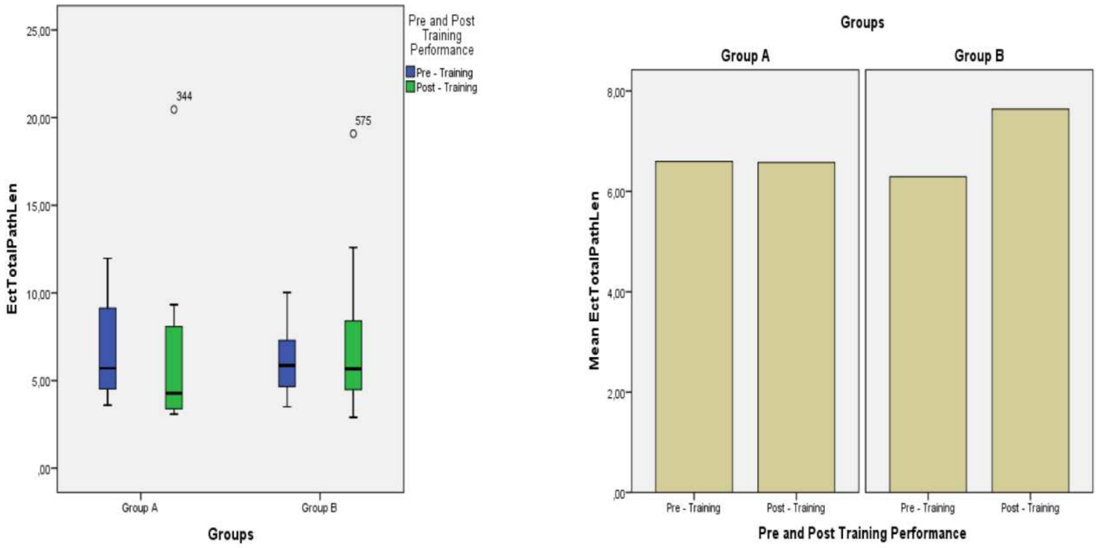


**Figure 3.3-11:** Boxplot and bar-graph comparing the Total Path Length (in meters) for participants in Group-A and participants in Group-B between pre-test and post-test assessment



**Group A, used higher movement economy in post-training as shown by the median in the boxplots**, while for group B, the median was roughly the same for the two sessions.

## 3.3.3. Correlation & Linear Regression Analysis of Analysis Parameters for Salpingotomy Task

### 3.3.3.1. Time of Task Completion

The **Table 3.3-9** below summarizes the Spearman's correlation analysis of time to complete test and the rest analysis parameters regarding salpingotomy, at the pre and post training session.

**Table 3.3-9:** Spearman's Correlation Analysis between the Time to Complete Task (in minutes) and the other analysis parameters, at the pre-training performance versus post-training performance, by group

| **10.1. Pre – Training Session** | | **Time of Cautery Used** | **Time of Cautery Used In Air** | **Total Blood Loss** | **Incision Length** | **Total Path Lenght** |
|---|---|---|---|---|---|---|
| **All Participants** | Correlation Coefficient | 0.43 | 0.301 | 0.648** | 0.381 | 0.797** |
| | Sig. (2-tailed) | 0.059 | 0.197 | 0.002 | 0.097 | 0.000 |
| **Group A** | Correlation Coefficient | 0.626 | 0.587 | 0.588 | 0.372 | 0.774** |
| | Sig. (2-tailed) | 0.053 | 0.074 | 0.074 | 0.29 | 0.009 |
| **Group B** | Correlation Coefficient | -0.16 | -0.178 | 0.801** | 0.399 | 0.834** |
| | Sig. (2-tailed) | 0.66 | 0.623 | 0.005 | 0.254 | 0.003 |

| **10.2. Post – Training Session** | | **Time of Cautery Used** | **Time of Cautery Used In Air** | **Total Blood Loss** | **Incision Length** | **Total Path Lenght** |
|---|---|---|---|---|---|---|
| **All Participants** | Correlation Coefficient | 0.844** | 0.832** | 0.650** | 0.634** | 0.847** |
| | Sig. (2-tailed) | 0.000 | 0.000 | 0.002 | 0.003 | 0.000 |
| **Group A** | Correlation Coefficient | 0.801** | 0.820** | 0.743* | 0.839** | 0.953** |
| | Sig. (2-tailed) | 0.005 | 0.004 | 0.014 | 0.002 | 0.000 |
| **Group B** | Correlation Coefficient | 0.888** | 0.839** | 0.577 | 0.677* | 0.851** |
| | Sig. (2-tailed) | 0.001 | 0.002 | 0.081 | 0.031 | 0.002 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The correlation analysis shows for Time to Complete the Task parameter that:

- **For all the participants, in pre-training session it correlates significantly (p=0.002 and p=0.000) with blood loss and the economy of movements.** On the other hand, **in the post-training session it significantly correlates with all the analysis parameters**.

- **Regarding Group A, in the post-training session, all the parameters correlate significantly to the time of the completion of the task, contrary to the pre-training performance where time correlate only with the economy of movements**.

- **Focusing on Group B, in the post-training session, all parameters except blood loss correlated significantly with completion time of the task**. In fact, blood loss correlation with time was significant in the pre-training session.

### Scatter plot of Completion Time versus Economy of Motions

- Focusing on the time to complete the task and the economy of motions, the graphs below show that **participants of Group A are more concentrated on the lower-left portion of the graph, so in pre-training as in post-training performance** (**Figures 3.3-12 to 3.3-15**). **Participants of Group B appear to be more widely dispersed on the pre-training performance, although they in turn show a concentration to the lower-left side in the post-training session, meaning that they use less time and more economy in their movements to perform the task**. K-means cluster analysis is statistically significant (p=0.000) in both cases, pre- and post-training and it shows two significant clusters.

**Figure 3.3-12: Scatter plot of Completion Time versus Economy of Motions, for participants in Group A and Group B, during Pre – Training**

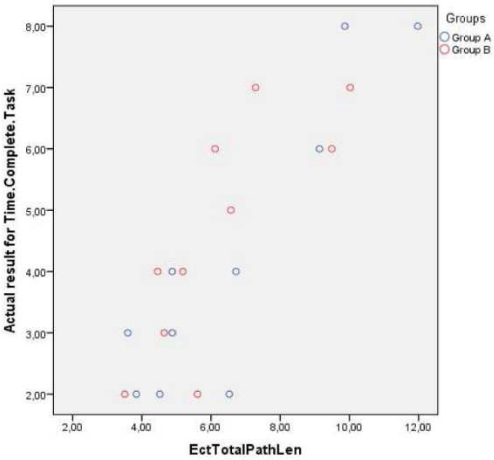


**Figure 3.3-13: Scatter plot of Completion Time versus Economy of Motions, for participants in Group A and Group B, during Post – Training**

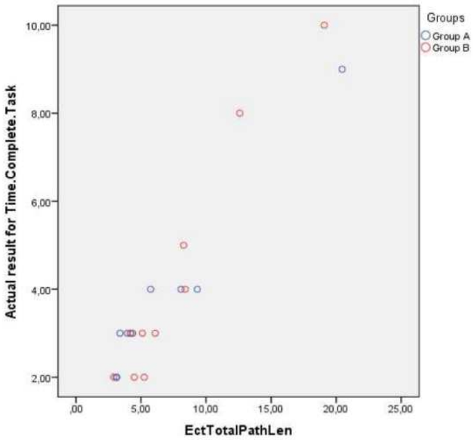


**Figure 3.3-14: K-Means cluster analysis of completion time versus Economy of motions, during Pre-Training**

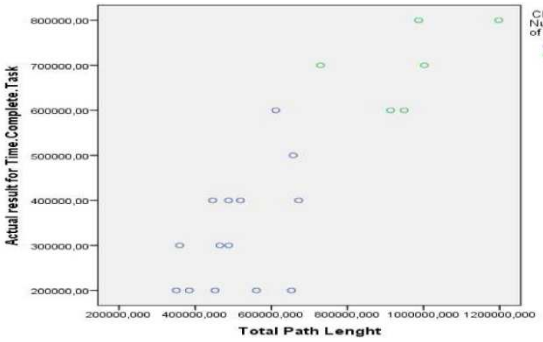


**Figure 3.3-15: K-Means cluster analysis of completion time versus Economy of motions, during Post-Training**

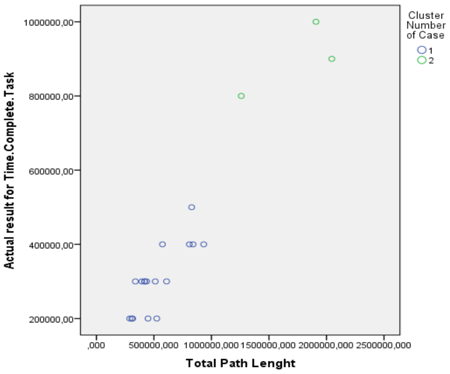
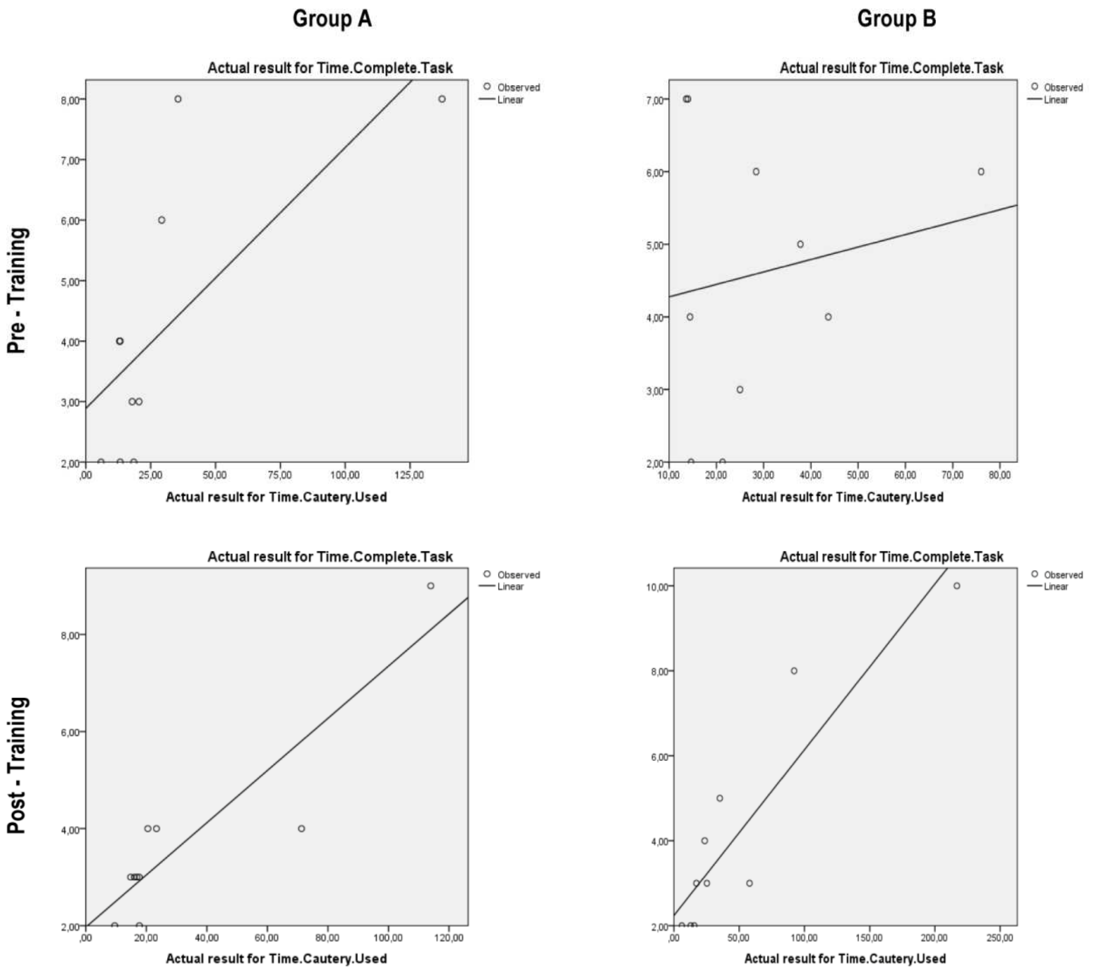


**Figure 3.3-16:** Linear regression for Time of Task Completion (in minutes) versus Time of Cautery Used (in seconds)

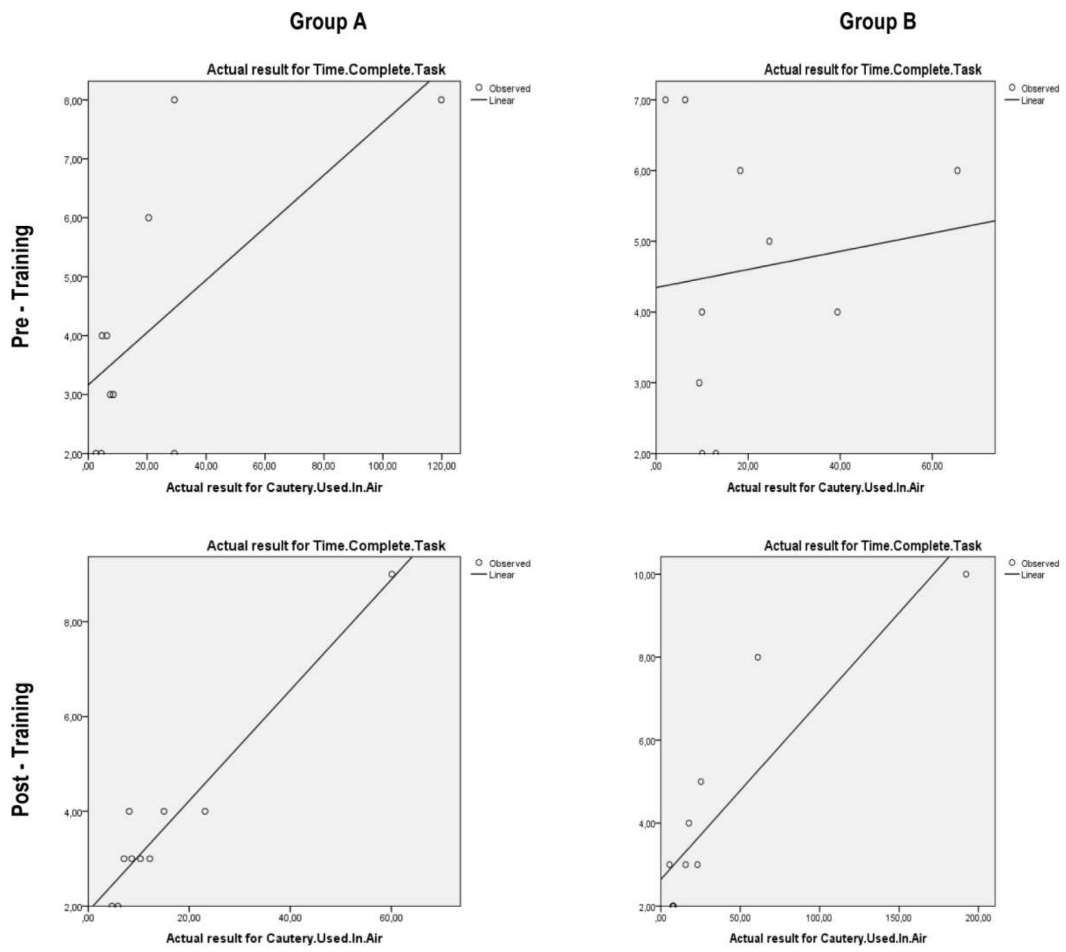


## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.500 | 0.022 |
| | B | 0.031 | 0.624 |
| **Post-Training** | A | 0.814 | 0.000 |
| | B | 0.828 | 0.000 |

Linear regression analysis exhibits that models have a very good fit and are significant at the post–training session for both groups. The model for Group A of the pre – training session is also significant.

**Figure 3.3-17:** Linear regression of Time for Task Completion (in minutes) versus Time for Cautery Used in Air (in seconds)

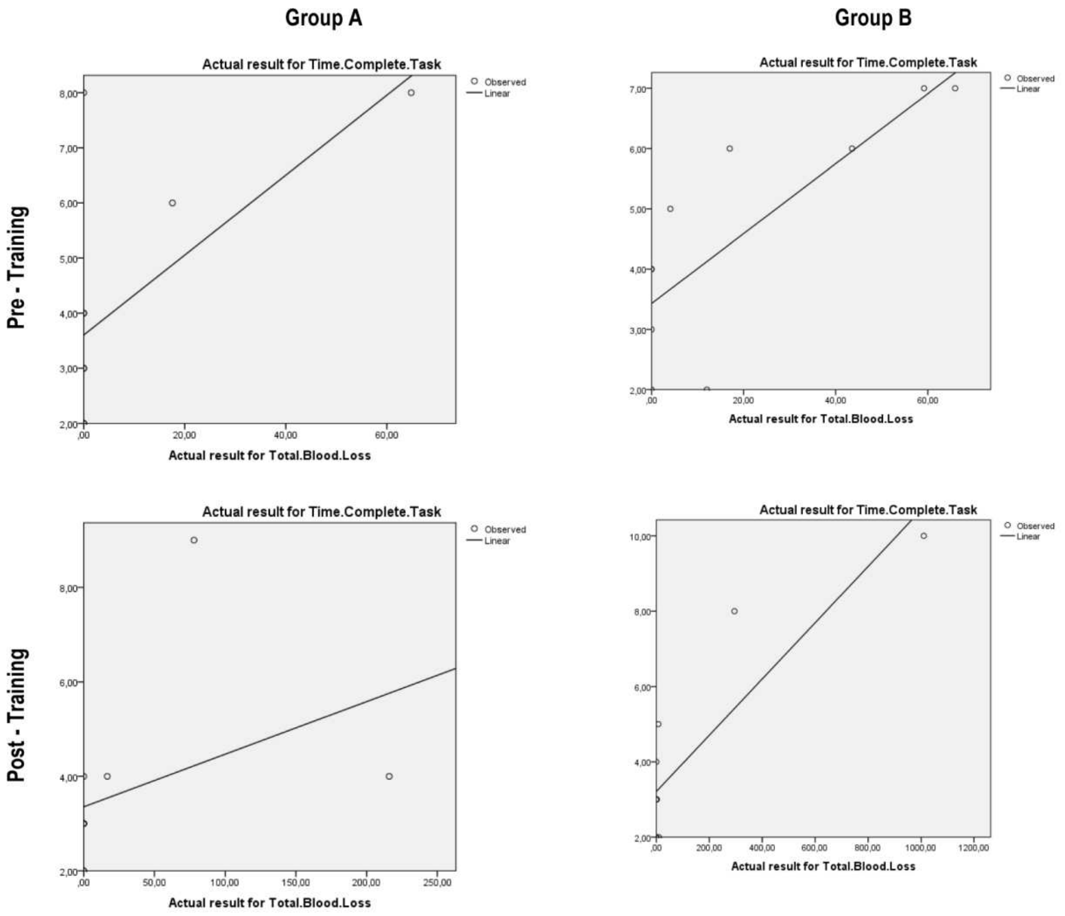


## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| Pre-Training | A | 0.450 | 0.034 |
| | B | 0.017 | 0.720 |
| Post-Training | A | 0.929 | 0.000 |
| | B | 0.799 | 0.000 |

Linear regression analysis exhibits that models have a very good fit and are significant at the post–training session for both groups. The model for Group A of the pre–training session is also significant.

**Figure 3.3-18:** Linear regression of Time for Task Completion (in minutes) versus Blood Loss (in cubic centimeters)

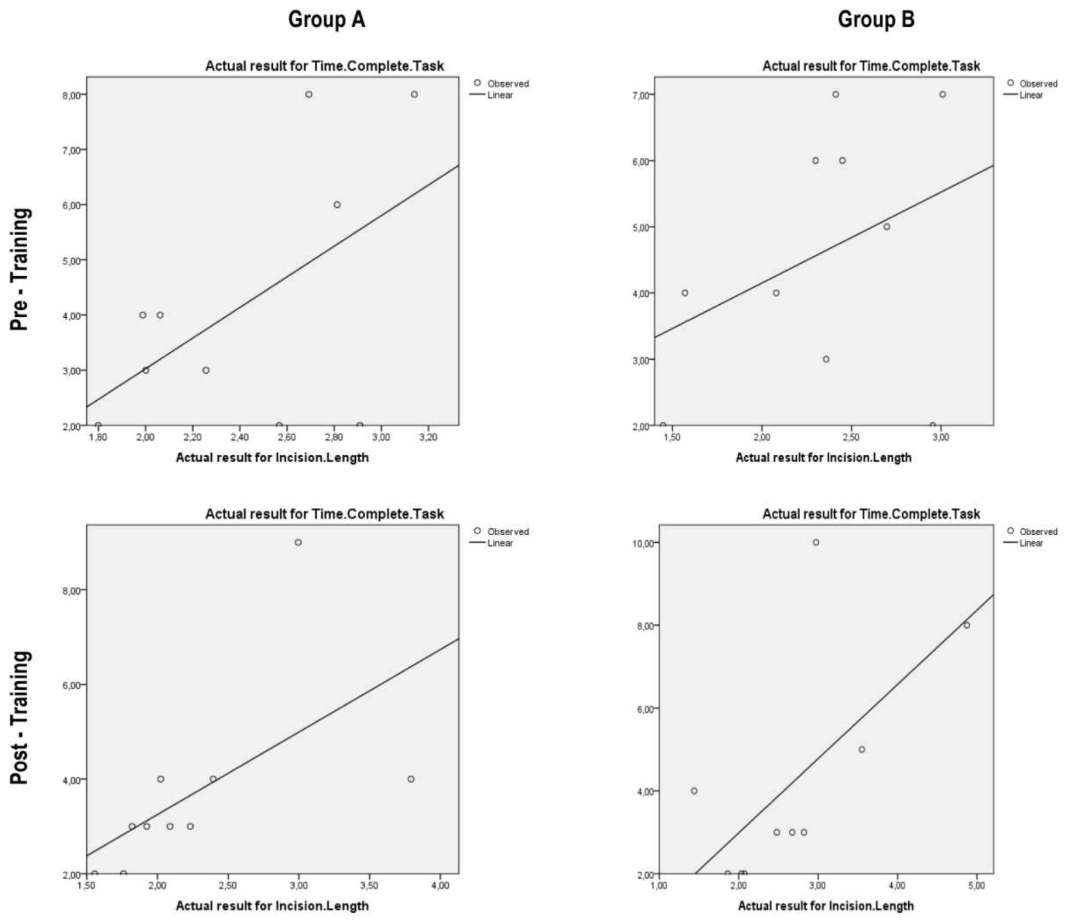


## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.406 | 0.047 |
| | B | 0.637 | 0.006 |
| **Post-Training** | A | 0.149 | 0.271 |
| | B | 0.769 | 0.001 |

The model is significant only in the case of Group B, for both sessions.

**Figure 3.3-19:** Linear regression of Time for Task Completion (in minutes) versus Incision Length (in centimeters)

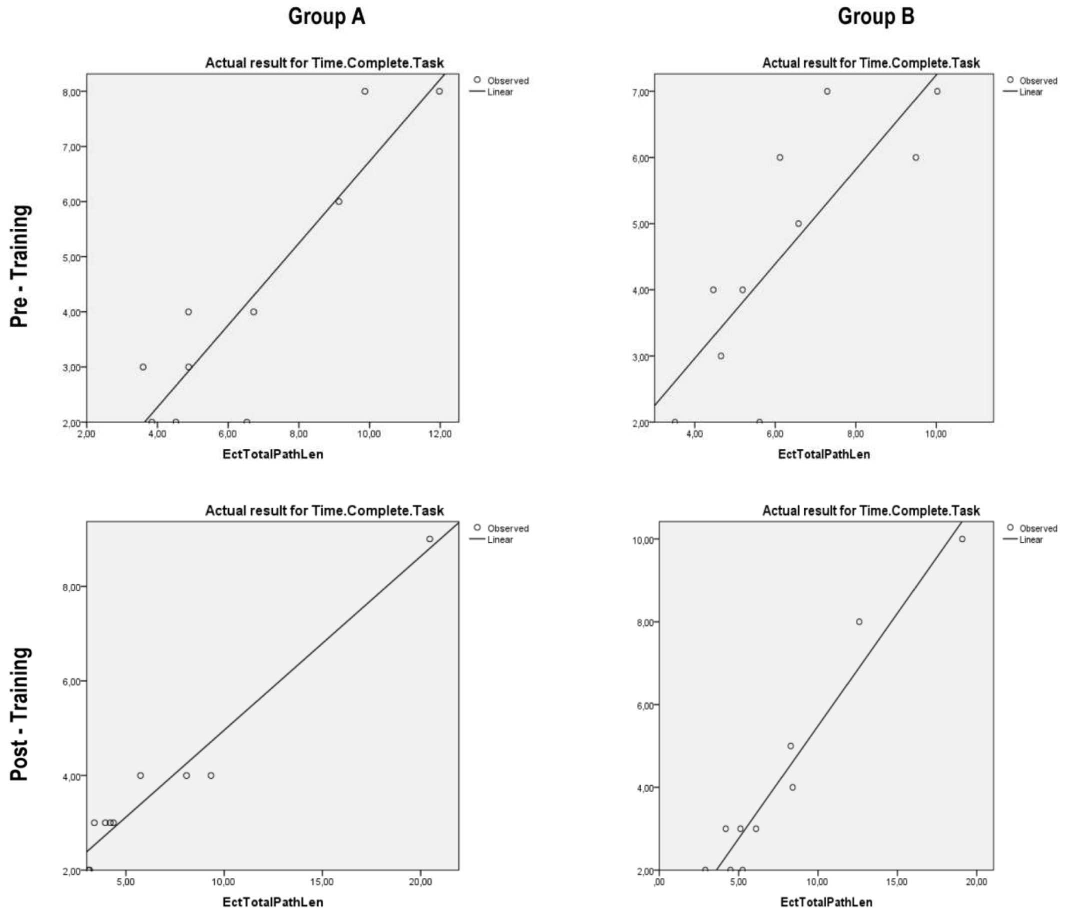


Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.297 | 0.104 |
| | B | 0.141 | 0.284 |
| **Post-Training** | A | 0.341 | 0.076 |
| | B | 0.414 | 0.045 |

The model is significant only for the post-training performance of Group B. Though the fit is not satisfactory.

**Figure 3.3-20:** Linear regression of Time for Task Completion (in minutes) versus Total Path Length (in meters)



Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.812 | 0.000 |
| | B | 0.641 | 0.005 |
| **Post-Training** | A | 0.963 | 0.000 |
| | B | 0.944 | 0.000 |

All the models are significant, with a good fit.

## 3.3.3.2. Actual Result for Time for Cautery Used

The **Table 3.3-10** below summarizes the Spearman's correlation analysis for Time for Cautery Used and the rest analysis parameters regarding salpingotomy, at the pre- and post-training session.

**Table 3.3-10:** Spearman's Correlation Analysis between Time of Cautery Used (in seconds) and the other analysis parameters, at the pre-training performance versus post-training performance, by group

| Pre-training Session | | Time for Cautery Used in.Air | Total Blood Loss | Incision Length | Total Path Lenght |
|---|---|---|---|---|---|
| **All Participants** | Correlation Coefficient | 0.714** | 0.353 | 0.414 | 0.418 |
| | Sig. (2-tailed) | 0.000 | 0.127 | 0.07 | 0.067 |
| **Group A** | Correlation Coefficient | 0.468 | 0.623 | 0.697* | 0.564 |
| | Sig. (2-tailed) | 0.172 | 0.054 | 0.025 | 0.09 |
| **Group B** | Correlation Coefficient | 0.927** | -0.256 | -0.079 | 0.03 |
| | Sig. (2-tailed) | 0.000 | 0.475 | 0.829 | 0.934 |

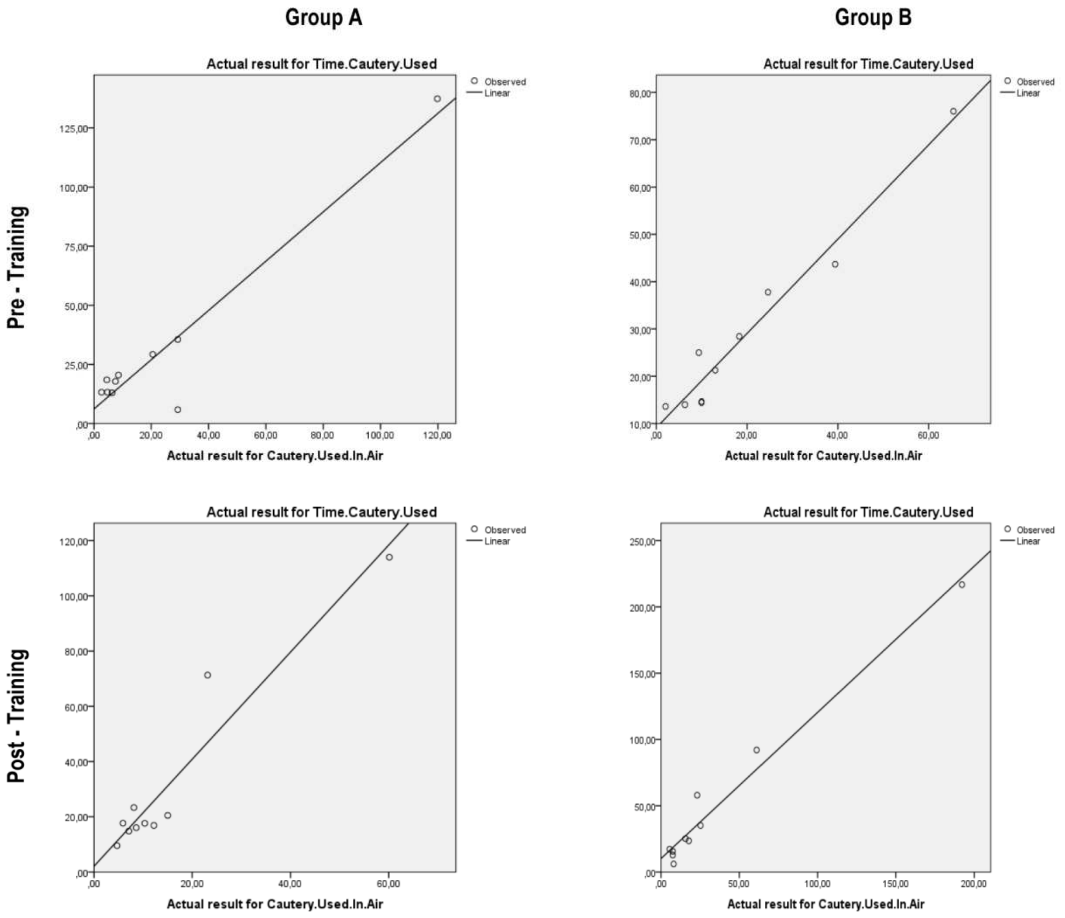
| Post-training session | | Time for Cautery Used In Air | Total Blood Loss | Incision Length | Total Path Lenght |
|---|---|---|---|---|---|
| **All Participants** | Correlation Coefficient | 0.862** | 0.667** | 0.654** | 0.820** |
| | Sig. (2-tailed) | 0.000 | 0.001 | 0.002 | 0.000 |
| **Group A** | Correlation Coefficient | 0.709* | 0.798** | 0.588 | 0.879** |
| | Sig. (2-tailed) | 0.022 | 0.006 | 0.074 | 0.001 |
| **Group B** | Correlation Coefficient | 0.855** | 0.55 | 0.782** | 0.770** |
| | Sig. (2-tailed) | 0.002 | 0.1 | 0.008 | 0.009 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

**The correlation of Time Cautery Used becomes more concrete on the post-training performance so for all participants as for the two groups separately**.

**Figure 3.3-21:** Linear regression of Time of Cautery Used (in seconds) versus Cautery Used in Air (in seconds)

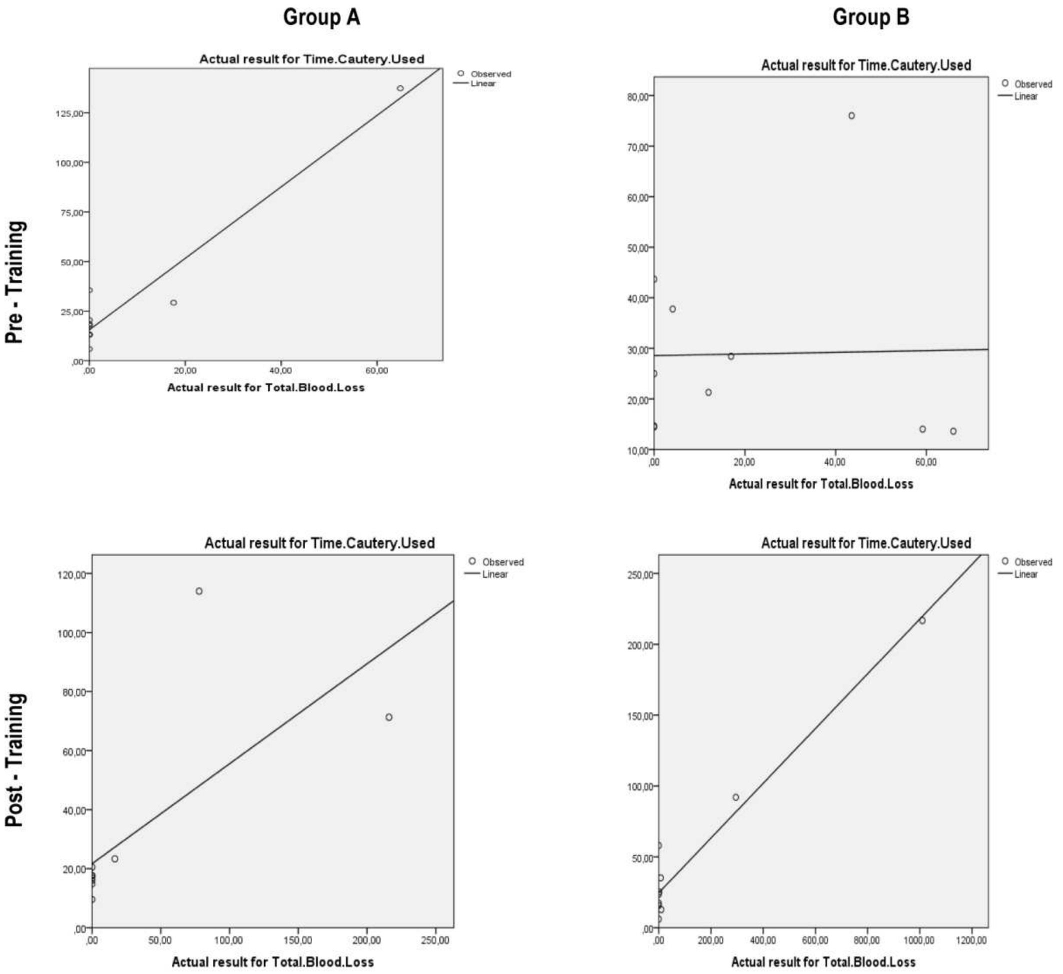


### Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.916 | 0.000 |
| | B | 0.961 | 0.000 |
| **Post-Training** | A | 0.913 | 0.000 |
| | B | 0.973 | 0.000 |

All the models are significant, with a very good fit.

**Figure 3.3-22:** Linear regression of Time of Cautery Used (in seconds) versus Blood Loss (in cubic centimeters)

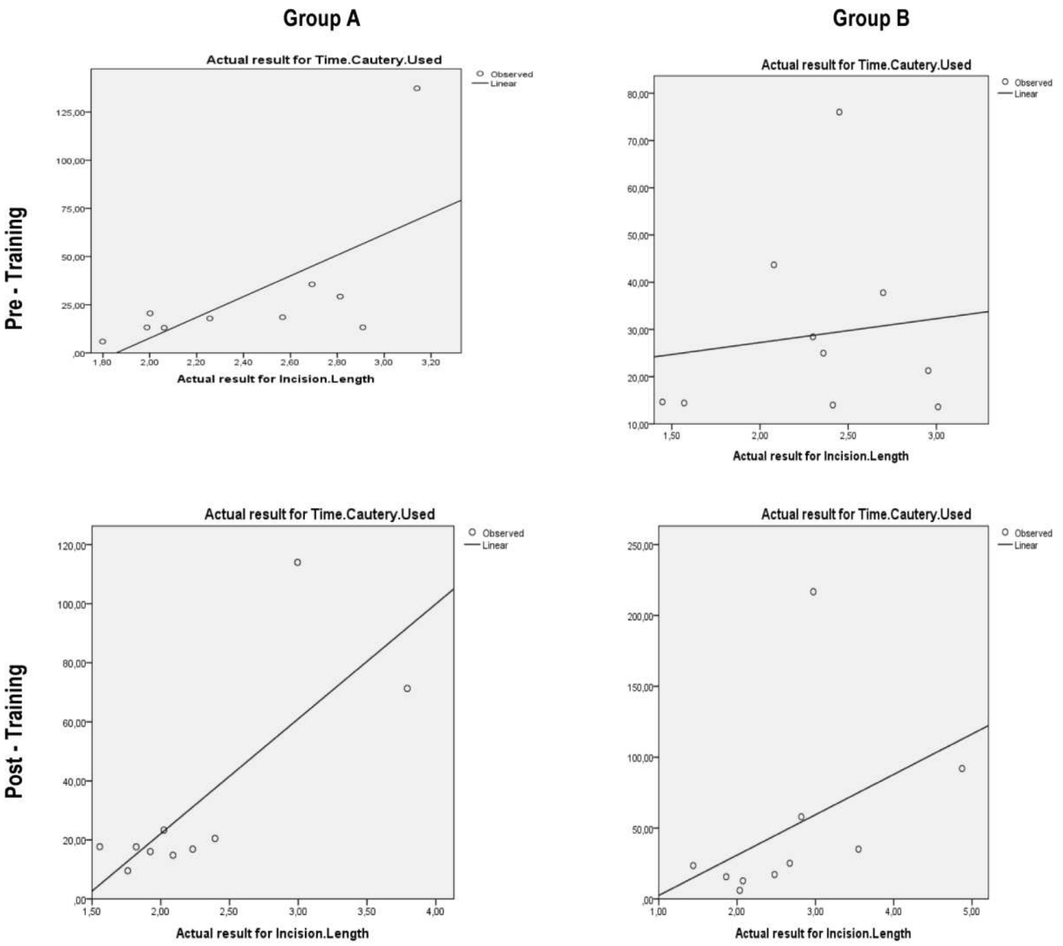


### Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.933 | 0.000 |
| | B | 0.000 | 0.962 |
| **Post-Training** | A | 0.489 | 0.024 |
| | B | 0.946 | 0.000 |

The models are significant except for the model for Group B of the pre – training session. **Notable model improvement for Group B, between pre and post training performance**.

**Figure 3.3-23:** Linear regression of Time of Cautery Used (in seconds) versus Incision Length (in centimeters)

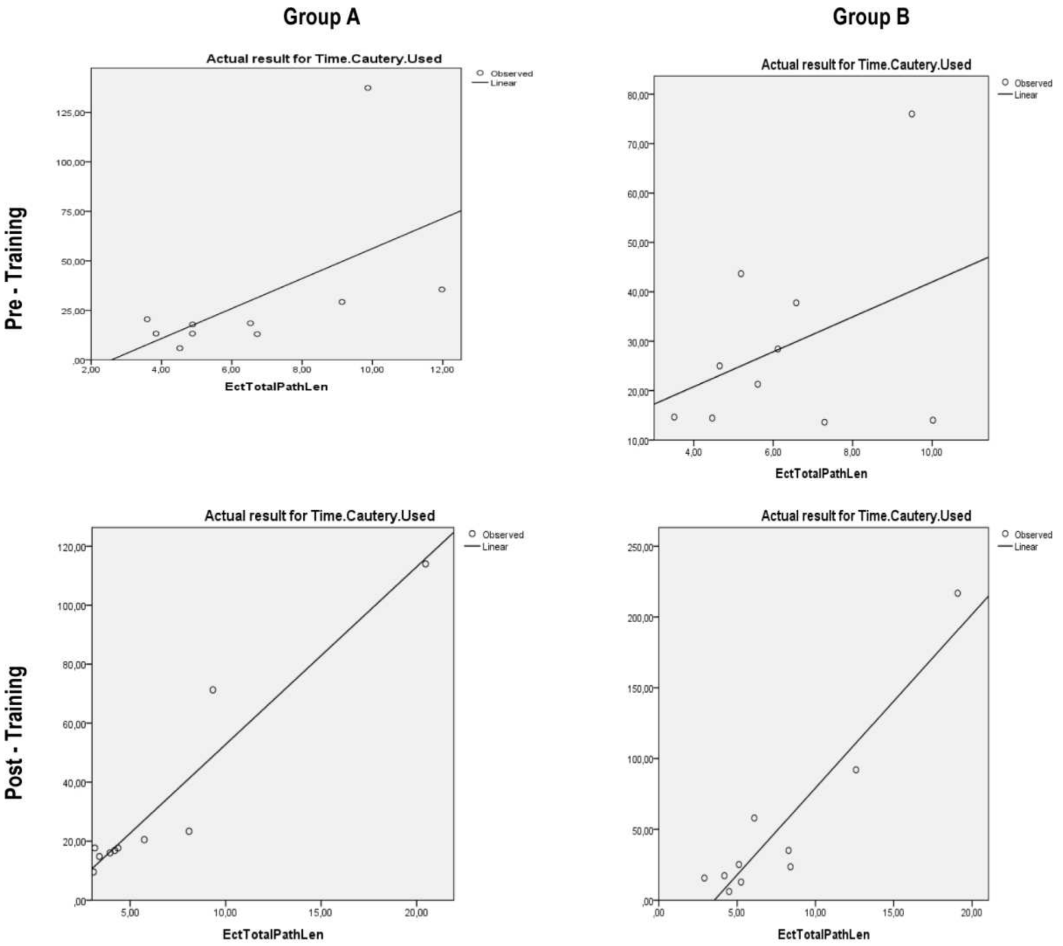


## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.415 | 0.044 |
| | B | 0.018 | 0.712 |
| **Post-Training** | A | 0.602 | 0.008 |
| | B | 0.192 | 0.205 |

The model is significant only for the Group A, for the two sessions.

**Figure 3.3-24:** Linear regression of Time of Cautery Used (in seconds) versus Total Path Length (in meters)



## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.313 | 0.093 |
| | B | 0.147 | 0.274 |
| **Post-Training** | A | 0.909 | 0.000 |
| | B | 0.882 | 0.000 |

**The model is significant for both groups of participants only in post-training session, with a very good fit**.

### 3.3.3.3. Actual Result for Time for Cautery Used in Air

The **Table 3.3-11** below summarizes the Spearman's correlation analysis for Time for Cautery Used in Air and the rest analysis parameters regarding salpingotomy, at the pre- and post-training session.

**Table 3.3-11:** Spearman's Correlation Analysis between Time for Cautery Used in Air (in seconds) and the other analysis parameters, at the pre-training performance versus post-training performance, by group

| **Pre-Training Session** | | **Total Blood Loss** | **Incision Length** | **Total Path Length** |
|---|---|---|---|---|
| **All Participants** | Correlation Coefficient | 0.189 | 0.041 | 0.264 |
| | Sig. (2-tailed) | 0.424 | 0.863 | 0.261 |
| **Group A** | Correlation Coefficient | 0.547 | 0.091 | 0.474 |
| | Sig. (2-tailed) | 0.102 | 0.802 | 0.166 |
| **Group B** | Correlation Coefficient | -0.213 | -0.115 | 0.018 |
| | Sig. (2-tailed) | 0.555 | 0.751 | 0.96 |

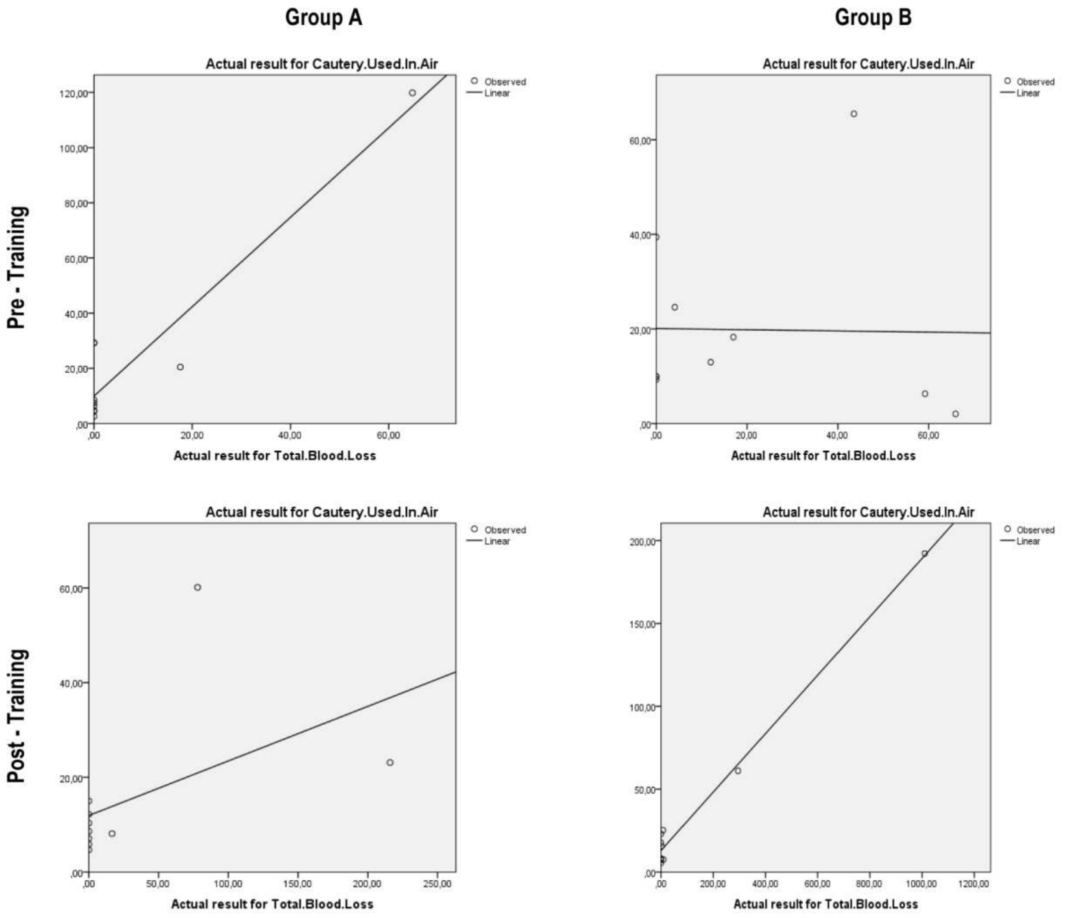
| **Post-Training Session** | | **Total Blood Loss** | **Incision Length** | **Total Path Length** |
|---|---|---|---|---|
| **All Participants** | Correlation Coefficient | 0.644** | 0.687** | 0.878** |
| | Sig. (2-tailed) | 0.002 | 0.001 | 0.000 |
| **Group A** | Correlation Coefficient | 0.559 | 0.855** | 0.867** |
| | Sig. (2-tailed) | 0.093 | 0.002 | 0.001 |
| **Group B** | Correlation Coefficient | 0.627 | 0.697* | 0.915** |
| | Sig. (2-tailed) | 0.052 | 0.025 | 0.000 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

According to the **Table 3.3-11**, **correlation is present for all the analysis parameters of post-training session in contradiction to pre-training session**, where no statistically significant correlation between the parameters exists.

**Figure 3.3-25:** Linear regression for Time for Cautery Used in Air (in seconds) versus Total Blood Loss (in cubic centimeters)

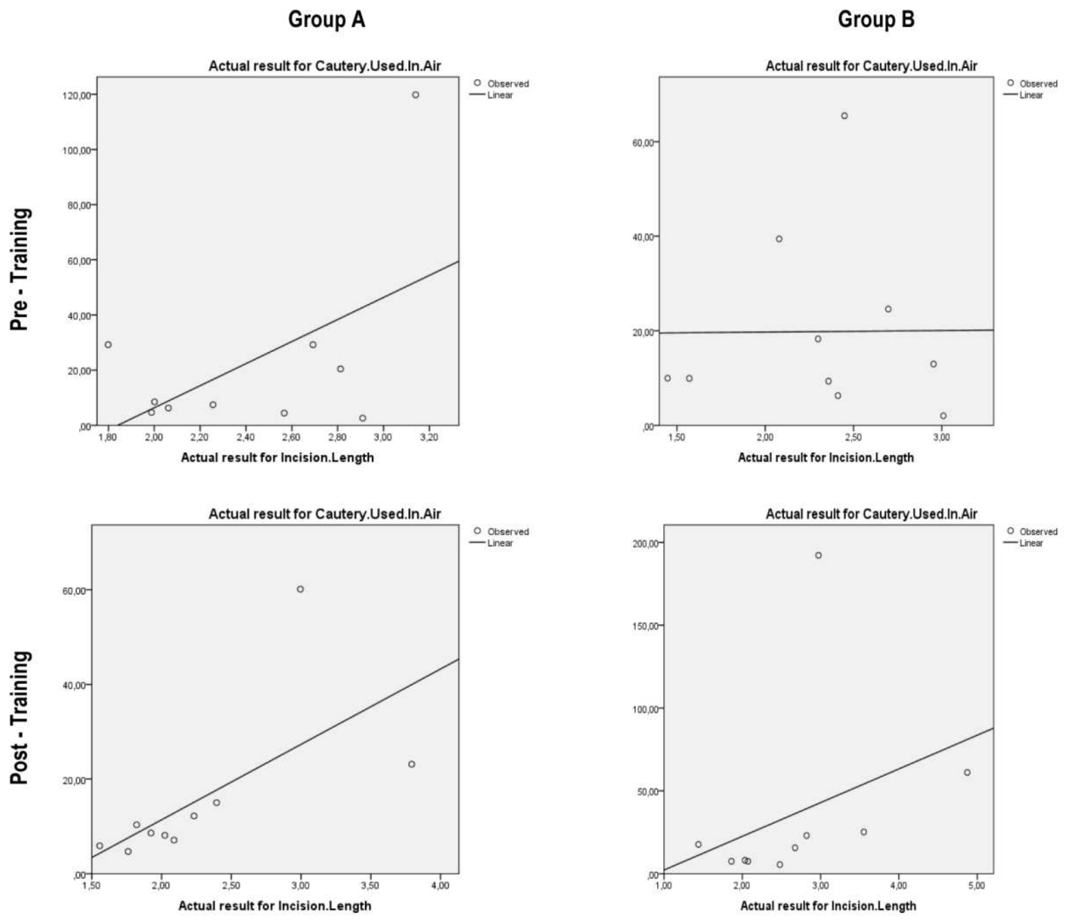


Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.892 | 0.000 |
| | B | 0.000 | 0.963 |
| **Post-Training** | A | 0.233 | 0.157 |
| | B | 0.986 | 0.000 |

The model is significant for group A in pre-training session and for group B in post-training session, with a very good fit.

**Figure 3.3-26:** Linear regression for Time for Cautery Used in Air (in seconds) versus Incision Length (in centimeters)

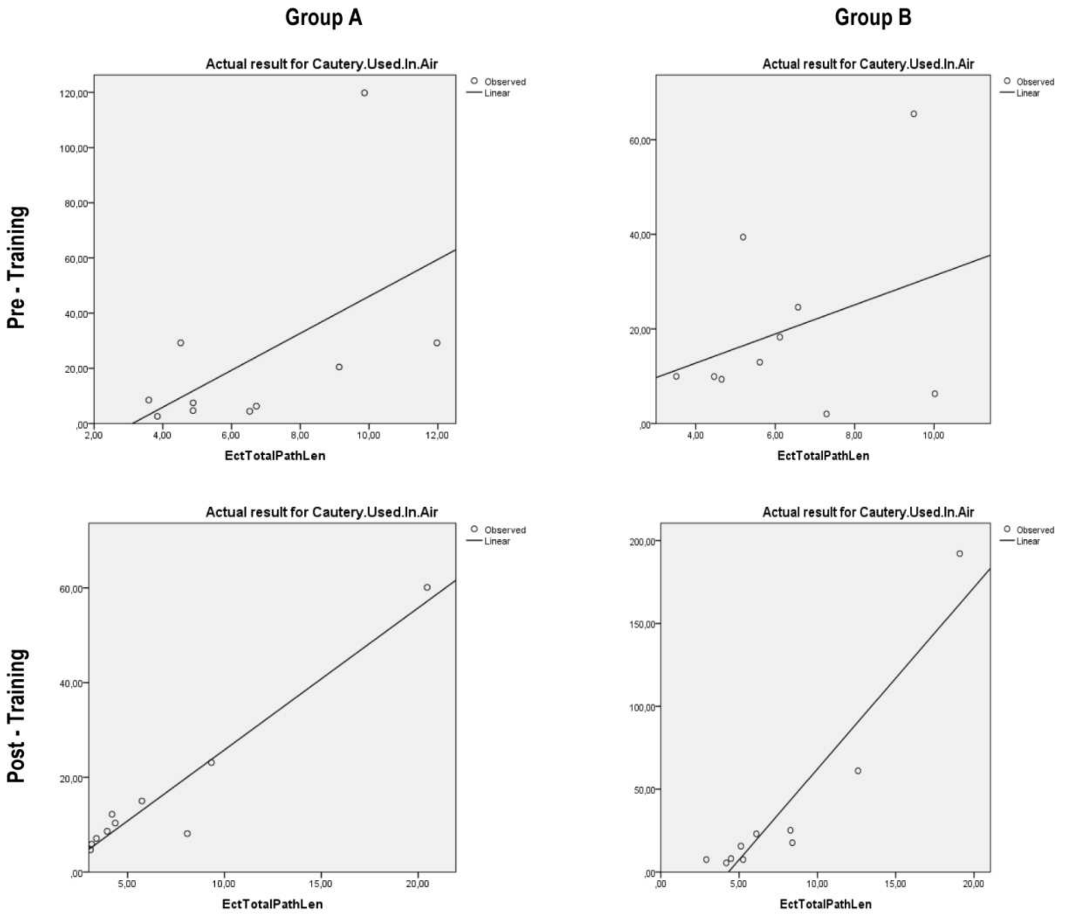


## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.271 | 0.123 |
| | B | 0.000 | 0.962 |
| **Post-Training** | A | 0.416 | 0.044 |
| | B | 0.123 | 0.321 |

The models are not significant (the model for group A in post-training session is marginally significant); neither do they provide a good fit.

**Figure 3.3-27:** Linear regression for Time for Cautery Used in Air (in seconds) versus Path Length (in meters)



Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| Pre-Training | A | 0.289 | 0.109 |
| | B | 0.115 | 0.338 |
| Post-Training | A | 0.929 | 0.000 |
| | B | 0.879 | 0.000 |

**The models are significant, for both groups, at the post-training session, with a very good fit.**

## 3.3.3.4. Actual Result for Blood Loss

The **Table 3.3-12** below summarizes the Spearman's correlation analysis of Blood Loss and the rest analysis parameters regarding salpingotomy, at the pre- and post-training session.

**Table 3.3-12:** Spearman's Correlation Analysis between Blood Loss (in cubic centimeters) and the other analysis parameters, at the pre-training performance versus post-training performance, by group

| **Pre-Training Session** | | **Incision Length** | **Total Path Lenght** |
|---|---|---|---|
| **All Participants** | Correlation Coefficient | 0.645** | 0.661** |
| | Sig. (2-tailed) | 0.002 | 0.002 |
| **Group A** | Correlation Coefficient | 0.623 | 0.528 |
| | Sig. (2-tailed) | 0.054 | 0.117 |
| **Group B** | Correlation Coefficient | 0.713* | 0.894** |
| | Sig. (2-tailed) | 0.021 | 0.000 |

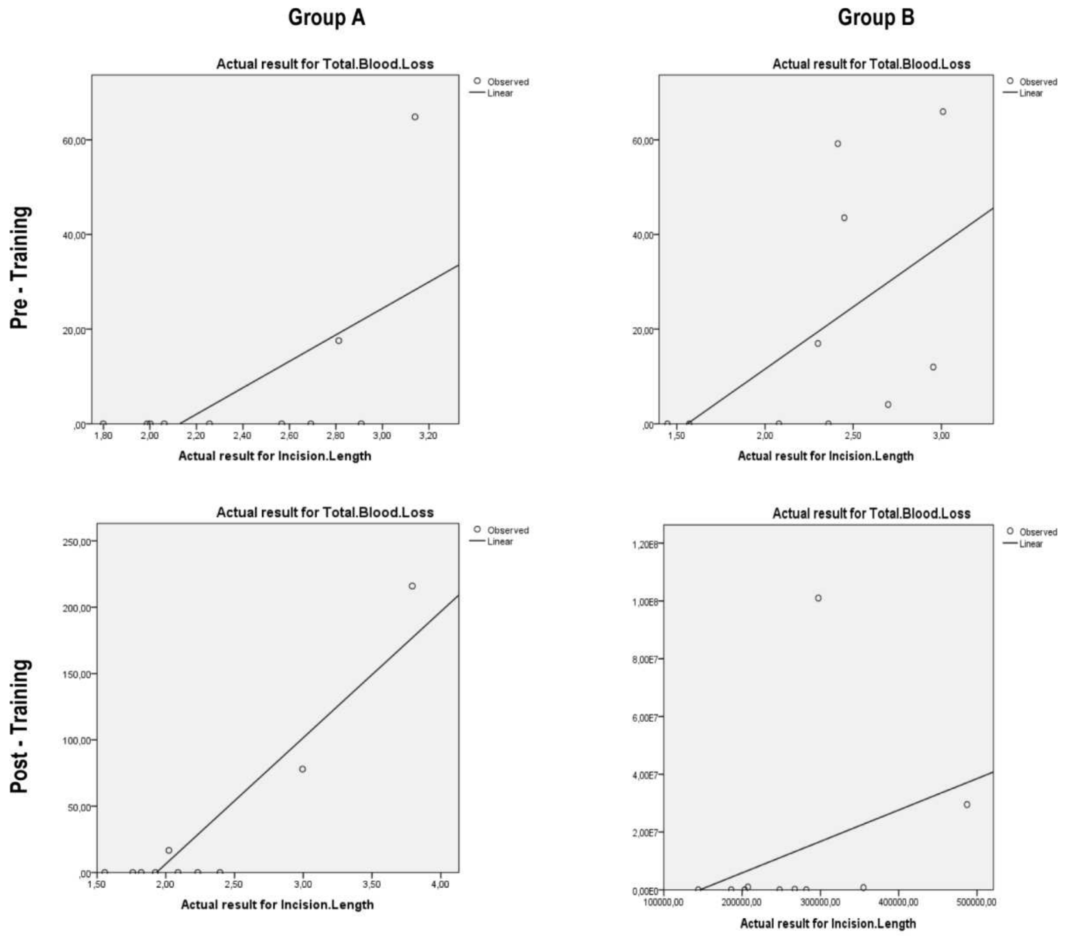
| **Post-Training Session** | | **Incision Length** | **Total Path Lenght** |
|---|---|---|---|
| **All Participants** | Correlation Coefficient | 0.665** | 0.765** |
| | Sig. (2-tailed) | 0.001 | 0.000 |
| **Group A** | Correlation Coefficient | 0.634* | 0.798** |
| | Sig. (2-tailed) | 0.049 | 0.006 |
| **Group B** | Correlation Coefficient | 0.679* | 0.666* |
| | Sig. (2-tailed) | 0.031 | 0.036 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

According to the **Table 3.3-12**, correlation is present (significant) for the all the participants for all the analysis parameters of pre- and post-training session. **The participants of Group A showed correlation for incision length and Total Path Length during the post-training session**. The participants of Group B showed correlation for incision length and Total Path Length during the pre-training and post-training session as well.

**Figure 3.3-28:** Linear regression for Blood Loss (in cubic centimeters) versus Incision Length (in centimeters)

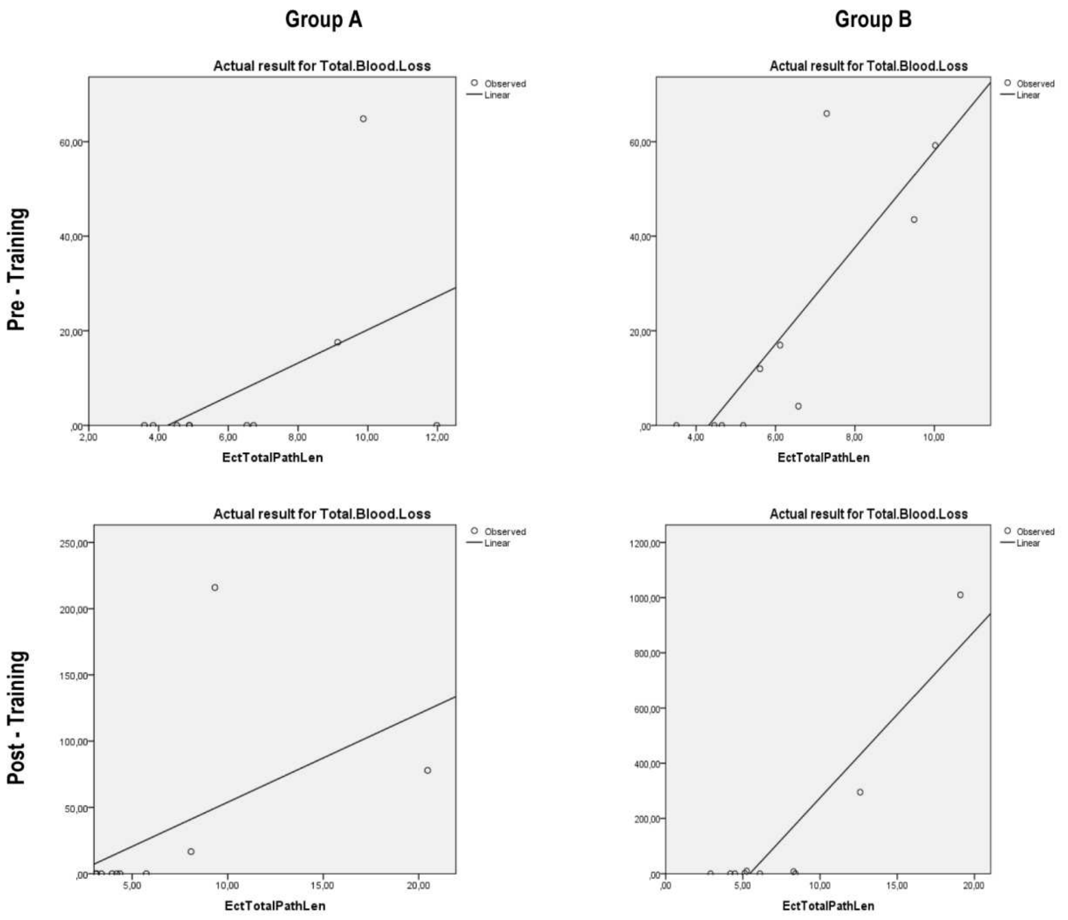


### Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| Pre-Training | A | 0.389 | 0.054 |
| | B | 0.274 | 0.121 |
| Post-Training | A | 0.844 | 0.000 |
| | B | 0.111 | 0.348 |

**Significant model only for post-training for Group A, with a very good fit.**

**Figure 3.3-29:** Linear regression for Blood Loss (in cubic centimeters) versus Total Path Length (in meters)



## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.236 | 0.154 |
| | B | 0.693 | 0.003 |
| **Post-Training** | A | 0.262 | 0.130 |
| | B | 0.842 | 0.000 |

Significant models for Group B, for both sessions.

### 3.3.3.5. Actual Result for Incision Length

The **Table 3.3-13** below summarizes the Spearman's correlation analysis of Incision Length and the rest analysis parameters regarding salpingotomy, at the pre and post training session.

**Table 3.3-13:** Spearman's Correlation Analysis between Incision Length (in centimeters) and the Total Path Length, at the pre-training performance versus post-training performance, by group

Pre-Training

| Incision Length | | Total Path Length |
|---|---|---|
| **Total** | Correlation Coefficient | 0.606** |
| | Sig. (2-tailed) | 0.005 |
| **Group A** | Correlation Coefficient | 0.515 |
| | Sig. (2-tailed) | 0.128 |
| **Group B** | Correlation Coefficient | 0.697* |
| | Sig. (2-tailed) | 0.025 |

Post-Training

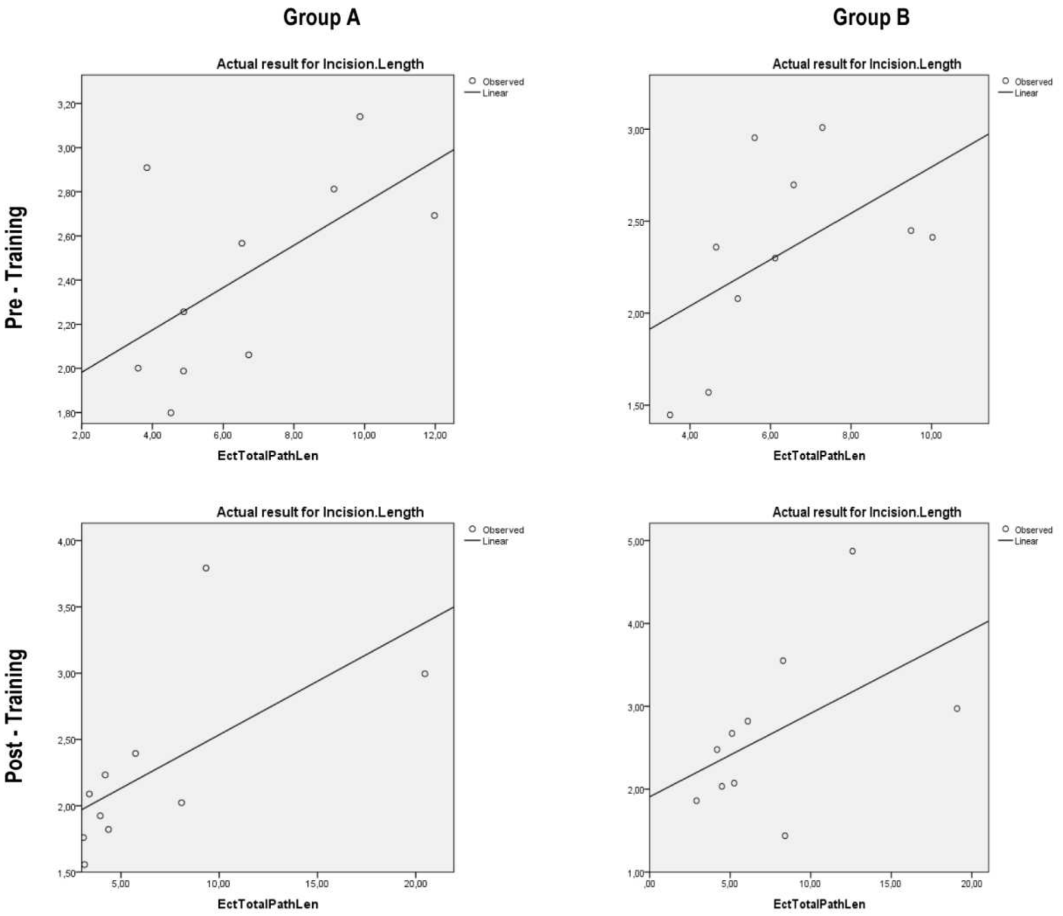
| Incision Length | | Total Path Length |
|---|---|---|
| **Total** | Correlation Coefficient | 0.647** |
| | Sig. (2-tailed) | 0.002 |
| **Group A** | Correlation Coefficient | 0.782** |
| | Sig. (2-tailed) | 0.008 |
| **Group B** | Correlation Coefficient | 0.552 |
| | Sig. (2-tailed) | 0.098 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

According to the **Table 3.3-13**, correlation is present (significant) for the all the participants for all the analysis parameters of pre- and post-training session. **The participants of Group A showed correlation during the post-training session**. The participants of Group B showed correlation during the pre-training session but not at the post-training session.

**Figure 3.3-30:** Linear regression for Incision Length (in centimeters) versus Total Path Length (in meters)



### Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.350 | 0.071 |
| | B | 0.266 | 0.127 |
| **Post-Training** | A | 0.411 | 0.046 |
| | B | 0.251 | 0.140 |

None of the models is statistically significant (**the model for group A in post-training session is marginally significant**).

At this section, the template that has been forwarded calls for a logistic regression analysis. This analysis cannot be performed because, as it is stated in the template, the depended variable is not a categorical one. We remind that such analysis is feasible only when the depended variable of the analysis is a categorical one. However, a Mann-Whitney test and an ANOVA test were made between different variables referred as covariates and the Salpingotomy task parameters (Time to complete the task, path length, incision length etc).

**Table 3.3-14:** Pre- & Post-training results for analysis parameters of Salpingotomy and Gender

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Male | | Female | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 3.36 | 1.36 | 5.67 | 2.18 | 0.010 | 0.020 |
| Time of Cautery Used | 22.54 | 19.46 | 38.37 | 38.39 | 0.247 | 0.095 |
| Time of Cautery Used in Air | 16.53 | 18.18 | 27.71 | 36.67 | 0.385 | 0.710 |
| Blood Loss | 19.86 | 20.88 | 44.90 | 25.35 | 0.202 | 0.143 |
| Incision Length | 2.19 | 0.51 | 2.60 | 0.35 | 0.060 | 0.067 |
| Left Path Length | 2.54 | 0.96 | 3.56 | 0.99 | 0.031 | 0.020 |
| Right Path Length | 2.74 | 0.96 | 4.30 | 1.70 | 0.018 | 0.016 |
| Total Path Length | 5.28 | 1.77 | 7.86 | 2.50 | 0.014 | 0.016 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Male | | Female | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 4.09 | 2.55 | 3.78 | 2.22 | 0.776 | 0.882 |
| Time of Cautery Used | 49.96 | 61.91 | 30.52 | 32.28 | 0.407 | 1.000 |
| Time of Cautery Used in Air | 31.94 | 55.60 | 19.91 | 17.33 | 0.565 | 0.600 |
| Blood Loss | 309.48 | 410.95 | 29.21 | 42.31 | 0.297 | 0.143 |
| Incision Length | 2.60 | 0.97 | 2.30 | 0.69 | 0.448 | 0.656 |
| Left Path Length | 3.10 | 2.40 | 3.27 | 3.00 | 0.888 | 0.882 |
| Right Path Length | 4.12 | 2.60 | 3.70 | 2.56 | 0.721 | 0.766 |
| Total Path Length | 7.22 | 4.90 | 6.97 | 5.43 | 0.916 | 0.941 |

**The analysis exhibits that there is a statistically significant deviation between the means of the analytical parameters gender-wise, regarding time to complete the task and the path lengths, on the pre-training. Male participants used less time to complete the task compared to female ones on the pre-training. In addition, male participants used less path length. On the post-training, these deviations appear to be alleviated, as neither ANOVA nor Mann Whitney test,**

**rendered any statistically significant result** (**Table 3.3-15**). The **Table 3.3-15** below summarizes the results of the pre- and post-training results of the salpingotomy's analysis parameters between the participants that are users and non-users of video games. Pre-training results did not showed significant differences. **On the post-training results, there is a marginal significance for Mann Whitney test while ANOVA shows a marginal non-significance for the incision length.** Due to the marginality of the significance results, the outcome is inconclusive.

**Table 3.3-16:** Pre- & Post-training results for analysis parameters of Salpingotomy and Video Games Users

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Video Games Users | | Video Games Not-Users | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 4.63 | 2.07 | 4.25 | 2.18 | 0.705 | 0.678 |
| Time of Cautery Used | 2.,07 | 22.57 | 30.72 | 34.66 | 0.851 | 0.851 |
| Time of Cautery Used in Air | 23.01 | 20.10 | 20.60 | 32.79 | 0.855 | 0.384 |
| Blood Loss | 21.52 | 20.12 | 43.90 | 26.78 | 0.262 | 0.250 |
| Incision Length | 2.30 | 0.48 | 2.42 | 0.50 | 0.585 | 0.571 |
| Left Path Length | 2.87 | 1.17 | 3.09 | 1.05 | 0.670 | 0.792 |
| Right Path Length | 3.61 | 1.77 | 3.33 | 1.42 | 0.695 | 0.851 |
| Total Path Length | 6.48 | 2.85 | 6.42 | 2.28 | 0.954 | 0.792 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Video Games Users | | Video Games Not-Users | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 4.88 | 2.64 | 3.33 | 2.02 | 0.156 | 0.057 |
| Time of Cautery Used | 60.15 | 69.40 | 28.58 | 30.21 | 0.178 | 0.135 |
| Time of Cautery Used in Air | 40.97 | 63.68 | 16.62 | 15.98 | 0.236 | 0.545 |
| Blood Loss | 307.97 | 412.34 | 31.72 | 40.04 | 0.305 | 0.393 |
| Incision Length | 2.91 | 0.97 | 2.17 | 0.63 | 0.053 | 0.039 |
| Left Path Length | 3.56 | 2.72 | 2.92 | 2.63 | 0.605 | 0.571 |
| Right Path Length | 4.88 | 2.69 | 3.30 | 2.30 | 0.177 | 0.082 |
| Total Path Length | 8.44 | 5.26 | 6.22 | 4.85 | 0.345 | 0.238 |

The **Table 3.3-16** below summarizes the results of the pre- and post-training results of the salpingotomy's analysis parameters between the participants that play or do not play a musical instrument. There are no statistically significant differences for the two groups during pre and post training performance.

**Table 3.3-17:** Pre- & Post-training results for analysis parameters of Salpingotomy and Players of Musical Instruments

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Players of Musical Instruments | | Not Players of Musical Instruments | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 4.00 | 1.90 | 4.57 | 2.21 | 0.589 | 0.602 |
| Time of Cautery Used | 25.36 | 8.63 | 31.50 | 35.39 | 0.684 | 0.444 |
| Time Cautery Used in Air | 13.30 | 9.07 | 25.10 | 32.45 | 0.399 | 0.602 |
| Blood Loss | 12.87 | 7.62 | 49.09 | 22.59 | 0.040 | 0.143 |
| Incision Length | 2.61 | 0.24 | 2.28 | 0.53 | 0.162 | 0.179 |
| Left Path Length | 3.02 | 1.05 | 3.00 | 1.13 | 0.973 | 0.841 |
| Right Path Length | 3.13 | 1.00 | 3.58 | 1.72 | 0.561 | 0.904 |
| Total Path Length | 6.14 | 1.83 | 6.57 | 2.72 | 0.729 | 0.904 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Players of Musical Instruments | | Not Players of Musical Instruments | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 3.83 | 2.64 | 4.00 | 2.32 | 0.889 | 0.659 |
| Time Cautery Used | 43.51 | 40.51 | 40.22 | 55.67 | 0.898 | 0.444 |
| Cautery Used in Air | 19.63 | 20.99 | 30.21 | 50.85 | 0.634 | 0.639 |
| Blood Loss | 98.63 | 108.48 | 267.83 | 432.77 | 0.542 | 0.786 |
| Incision Length | 2.56 | 0.80 | 2.43 | 0.89 | 0.762 | 0.602 |
| Left Path Length | 3.50 | 3.62 | 3.04 | 2.21 | 0.727 | 0.904 |
| Right Path Length | 4.02 | 3.29 | 3.89 | 2.27 | 0.918 | 0.779 |
| Total Path Length | 7.52 | 6.76 | 6.93 | 4.35 | 0.815 | 0.659 |

The performance results between those that **play some team sport and those that do not, exhibit statistically significant results on the pre-training for time to complete the task and the path lengths**. In fact, **on the pre-training, players of team sports used significantly less time to complete the task and less left and right path lengths**. On the other hand, **on the post-training, these differences become not significant**, although players of team sports continue to use notably less time to complete the task and less path lengths (**Table 3.3-17**).

**Table 3.3-18:** Pre- & Post-training results for analysis parameters of Salpingotomy and Players of Team Sports

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Players of Team Sports | | Not Players of Team Sports | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 3.00 | 1.10 | 6.11 | 1.69 | 0.000 | 0.001 |
| Time Cautery Used | 20.61 | 11.27 | 40.72 | 41.15 | 0.136 | 0.230 |
| Cautery Used in Air | 13.83 | 11.94 | 31.01 | 38.40 | 0.176 | 0.412 |
| Blood Loss | 8.03 | 5.59 | 44.67 | 22.68 | 0.075 | 0.071 |
| Incision Length | 2.26 | 0.48 | 2.52 | 0.47 | 0.247 | 0.230 |
| Left Path Length | 2.42 | 0.78 | 3.72 | 0.98 | 0.004 | 0.002 |
| Right Path Length | 2.64 | 0.72 | 4.42 | 1.71 | 0.006 | 0.012 |
| Total Path Length | 5.06 | 1.19 | 8.14 | 2.57 | 0.002 | 0.010 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Players of Team Sports | | Not Players of Team Sports | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 3.00 | 0.77 | 5.11 | 3.10 | 0.078 | 0.175 |
| Time Cautery Used | 26.19 | 19.51 | 59.57 | 70.01 | 0.146 | 0.370 |
| Cautery Used in Air | 11.31 | 6.68 | 48.27 | 62.01 | 0.064 | 0.051 |
| Blood Loss | 80.71 | 117.19 | 278.58 | 425.88 | 0.473 | 1.000 |
| Incision Length | 2.17 | 0.66 | 2.83 | 0.94 | 0.082 | 0.067 |
| Left Path Length | 2.13 | 0.64 | 4.46 | 3.51 | 0.083 | 0.230 |
| Right Path Length | 3.25 | 1.68 | 4.77 | 3.19 | 0.188 | 0.261 |
| Total Path Length | 5.37 | 2.28 | 9.23 | 6.62 | 0.086 | 0.201 |

As depicted on **Table 3.3-18**, residency does not appear to impact the performance of the participants, neither on pre- nor on post- training. The same holds for previous laparoscopic training (**Table 3.3-19**).

**Table 3.3-19:** Pre- & Post-training results for analysis parameters of Salpingotomy and Residency

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Junior | | Senior | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 4.43 | 1.72 | 4.38 | 2.33 | 0.966 | 0.817 |
| Time Cautery Used | 21.35 | 9.05 | 34.14 | 36.03 | 0.373 | 0.757 |
| Cautery Used in Air | 12.42 | 6.82 | 26.49 | 33.54 | 0.292 | 0.757 |
| Blood Loss | 23.05 | 24.67 | 47.97 | 22.74 | 0.188 | 0.114 |
| Incision Length | 2.29 | 0.46 | 2.42 | 0.50 | 0.553 | 0.588 |
| Left Path Length | 2.96 | 1.00 | 3.03 | 1.15 | 0.893 | 1.000 |
| Right Path Length | 3.20 | 1.15 | 3.57 | 1.73 | 0.620 | 0.877 |
| Total Path Length | 6.16 | 2.05 | 6.60 | 2.71 | 0.713 | 1.000 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Junior | | Senior | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 3.57 | 1.99 | 4.15 | 2.58 | 0.611 | 0.588 |
| Time Cautery Used | 33.17 | 30.73 | 45.53 | 59.28 | 0.615 | 0.938 |
| Cautery Used in Air | 20.70 | 20.72 | 29.72 | 51.00 | 0.685 | 0.831 |
| Blood Loss | 148.58 | 207.34 | 222.98 | 393.72 | 0.813 | 0.857 |
| Incision Length | 2.66 | 1.05 | 2.36 | 0.74 | 0.471 | 0.643 |
| Left Path Length | 2.68 | 1.55 | 3.44 | 3.06 | 0.547 | 0.817 |
| Right Path Length | 3.15 | 1.56 | 4.35 | 2.89 | 0.322 | 0.699 |
| Total Path Length | 5.83 | 3.07 | 7.80 | 5.79 | 0.416 | 0.757 |

**Table 3.3-20:** Pre- & Post-training results for analysis parameters of Salpingotomy and Laparoscopic Training

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Previous Laparoscopic Training | | No Previous Laparoscopic Training | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 2.75 | 0.96 | 4.81 | 2.10 | 0.076 | 0.080 |
| Time Cautery Used | 23.32 | 13.77 | 31.25 | 32.71 | 0.646 | 0.963 |
| Cautery Used in Air | 13.51 | 17.39 | 23.58 | 29.95 | 0.532 | 0.290 |
| Blood Loss | - | - | 35.51 | 25.68 | - | - |
| Incision Length | 2.45 | 0.36 | 2.36 | 0.51 | 0.728 | 0.820 |
| Left Path Length | 2.25 | 0.75 | 3.19 | 1.08 | 0.121 | 0.099 |
| Right Path Length | 2.86 | 0.79 | 3.59 | 1.65 | 0.411 | 0.617 |
| Total Path Length | 5.11 | 1.11 | 6.78 | 2.60 | 0.234 | 0.385 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Previous Laparoscopic Training | | No Previous Laparoscopic Training | | T-test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 3.00 | 1.15 | 4.19 | 2.54 | 0.380 | 0.554 |
| Time Cautery Used | 30.53 | 27.78 | 43.88 | 55.17 | 0.649 | 1.000 |
| Cautery Used in Air | 12.85 | 9.01 | 30.61 | 48.14 | 0.481 | 0.469 |
| Blood Loss | - | - | 202.72 | 371.09 | - | - |
| Incision Length | 2.14 | 1.11 | 2.55 | 0.79 | 0.396 | 0.122 |
| Left Path Length | 2.32 | 0.87 | 3.39 | 2.87 | 0.478 | 0.820 |
| Right Path Length | 3.67 | 2.49 | 4.00 | 2.61 | 0,826 | 0.750 |
| Total Path Length | 5.99 | 3.34 | 7.39 | 5.39 | 0.631 | 0.750 |

### 3.3.4. Analysis for the Laparoscopic Salpingectomy Task on the LapVR simulator

Most of the residents found as very good the choice of the task (85%). The **Table 3.3-20a** depicts the face validity for the laparoscopic salpingectomy on the LapVRT simulator and gives the mean and standard deviation of the scores obtained from the feedback questionnaire between the participants from the Group A and Group B respectively. The Mann–Whitney U test, comparing the difference of opinion between participants in group A and group B, did not show any significance for all of the questions. This suggests that there was no difference of opinion between the two groups on all the questions. Participants rated depth perception as "Very Good-Rather good" by 45%, as "Moderate" by 30% and as "Rather bad-Very bad" by 25%. The lowest mean score received was 2.45, recorded amongst the participant that find depth perception as "Rather bad-Very bad", addressing the problem of the Lap-VRT simulator in this aspect. Low mean score was received for the realism of force feedback (haptics) (3.80) (**Table 3.3-20b**). The highest mean received for all of the questions was 4.40 for the software design. High mean score was received for the realism of instruments simulation (4.35). Strong agreement among the subjects was evident from the low standard deviation. The maximum standard deviation was 1.281, which was reported for the force feedback (haptics).

**Table 3.3-21a:** Face validity: Descriptive statistics obtained from the feedback questionnaire

| **Questionnaire (Training Realism)** | **Total** | | **Group A** | | **Group B** | | **p-values of Mann - Whitney U Test** |
|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | |
| Software Design | 4.40 | 0.821 | 4.40 | 0.516 | 4.40 | 1.075 | 0.529 |
| Realism of the Surgical Procedure | 4.20 | 0.834 | 4.10 | 0.738 | 4.30 | 0.949 | 0.436 |
| Realism of Peritoneal Cavity Anatomy | 4.20 | 0.768 | 4.00 | 0.816 | 4.40 | 0.699 | 0.315 |
| Realism of Camera Simulation | 4.25 | 0.786 | 4.30 | 0.823 | 4.20 | 0.789 | 0.796 |
| Realism of Instruments Simulation | 4.35 | 0.813 | 4.50 | 0.527 | 4.20 | 1.033 | 0.739 |
| Realism of Instruments Freedom/Movements | 4.10 | 0.788 | 4.00 | 0.816 | 4.20 | 0.789 | 0.631 |
| Realism of force feedback (haptics) | 3.80 | 1.281 | 3.90 | 1.287 | 3.70 | 1.337 | 0.739 |
| Realism of reaction to manipulation | 3.95 | 1.099 | 3.90 | 0.994 | 4.00 | 1.247 | 0.684 |

**Table 3.3-20b:** Face validity: Descriptive statistics obtained from the feedback questionnaire in terms of the Depth Perception

| Questionnaire (Training Capacities) | Total | | Group A | | Group B | | p-values of Mann - Whitney U Test |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| **The Depth Perception** | | | | | | | |
| score 4–5 | 4.33 | 0.500 | 4.4 | 0.548 | 4.25 | 0.5 | 0.730 |
| score 1–3 | 2.45 | 0.688 | 2.2 | 0.837 | 2.67 | 0.516 | 0.429 |

The **Table 3.3-21** depicts the content validity for the laparoscopic salpingectomy on the Lap-VRT simulator. The question if the training capacity was reached with this task and the procedure was functioning was rated above a score of 3 on the 5-point Likert scale with eighty percent (80%) of the participants to score 4–5 on the 5-point Likert scale compared to a low–moderate score (1–3) by 20%. The Mann–Whitney U test, comparing the difference of opinion between participants in group A and group B, did not show any significance for this question suggesting that there was no difference of opinion between the two groups.

**Table 3.3-22:** Content validity: Descriptive statistics obtained from the feedback questionnaire

| Questionnaire (Training Capacities) | Total | | Group A | | Group B | | p-values of Mann - Whitney U Test |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| **Training Capacity Reached (Procedural Functioning)** | | | | | | | |
| score 4–5 | 4.5 | 0.516 | 4.29 | 0.488 | 4.67 | 0.5 | 0.210 |
| score 1–3 | 3 | - | 3 | - | 3 | - | - |

The comparison of the results of the pre-training tests between the Group-A and the Group-B are given in **Tables 3.3-22 and 3.3-23**. **Table 3.3-22** shows the results of all participants, while **Table 23** **shows the results of the participants who successfully completed the operation during the pre-training test (40% for each group)**. There were no significant differences between the participants in Group A and Group B with the One way ANOVA test except for **the percentage of adhesions ripped by**

**participants of Group-B that was significantly higher than Group-A** (for all the participants).

**Table 3.3-23:** Comparison of the pre-training results between the Group-A and the Group-B among ALL PARTICIPANTS

| **Parameters** | **Group A** | | **Group B** | | **One Way ANOVA** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |
| Time for Task Completion (min) | 12.20 | 4.87 | 13.50 | 5.10 | 0.567 |
| Time for Cautery Used (sec) | 119.66 | 71.36 | 131.81 | 56.47 | 0.678 |
| Time for Cautery Used in Air (sec) | 45.62 | 51.65 | 54.33 | 24.82 | 0.636 |
| Total Blood Loss (cc) | 585.27 | 341.84 | 505.77 | 279.15 | 0.576 |
| Percentage of Adhesions Ripped (%) | 2.60 | 1.65 | 14.00 | 12.29 | 0.009 |
| Percentage of Adhesions Lysed (%) | 94.30 | 18.02 | 99.40 | 0.97 | 0.383 |
| Left Path Length (m) | 8.21 | 4.08 | 7.13 | 3.69 | 0.544 |
| Right Path Length (m) | 12.16 | 4.95 | 13.20 | 4.37 | 0.626 |
| Total Path Length (Left & Right) (m) | 20.37 | 8.09 | 20.33 | 7.27 | 0.991 |

**Table 3.3-24:** Comparison of the pre-training results between the Group-A and the Group-B among PARTICIPANTS WHO SUCCESSFULLY COMPLETED THE TASK

| **Parameters** | **Group A** | | **Group B** | | **One Way ANOVA** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |
| **Percentage of Participants who Completed the Operation (%)** | **40%** | - | **40%** | - | - |
| Time for Task Completion (min) | 11.00 | 5.35 | 14.00 | 4.97 | 0.443 |
| Time for Cautery Used (sec) | 147.23 | 105.04 | 170.08 | 45.12 | 0.703 |
| Time for Cautery Used in Air (sec) | 66.55 | 80.69 | 64.46 | 12.45 | 0.961 |
| Total Blood Loss (cc) | 612.17 | 339.16 | 542.31 | 307.88 | 0.771 |
| Percentage of Adhesions Ripped (%) | 3.00 | 1.15 | 21.00 | 16.69 | 0.075 |
| Percentage of Adhesions Lysed (%) | 100.00 | 0.00 | 100.00 | 0.00 | - |
| Left Path Length (m) | 8.28 | 5.51 | 8.11 | 3.91 | 0.963 |
| Right Path Length (m) | 12.97 | 6.52 | 15.36 | 4.16 | 0.560 |
| Total Path Length (Left & Right) (m) | 21.25 | 11.00 | 23.47 | 6.70 | 0.742 |

The comparison of the results of the post-training tests between the Group-A and the Group-B for all the participants are given in **Table 3.3-24**. **Laparoscopic salpingectomy was completed faster by the participants in the group A than by participants in Group B**. There were no significant differences between the participants in Group A and Group B.

**Table 3.3-25:** Construct validity: Comparison of the post-training results between the Group-A and the Group-B among ALL PARTICIPANTS

| Parameters | Group A | | Group B | | One Way ANOVA |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Time for Task Completion (min) | 10.83 | 5.30 | 12.10 | 4.61 | 0.574 |
| Time for Cautery Used (sec) | 157.79 | 90.65 | 159.55 | 88.46 | 0.965 |
| Time for Cautery Used in Air (sec) | 57.55 | 55.60 | 44.69 | 28.74 | 0.524 |
| Total Blood Loss (cc) | 405.87 | 210.23 | 398.05 | 211.47 | 0.935 |
| Percentage of Adhesions Ripped (%) | 2.85 | 3.76 | 12.20 | 25.57 | 0.267 |
| Percentage of Adhesions Lysed (%) | 97.40 | 7.55 | 99.80 | 0.63 | 0.329 |
| Left Path Length (m) | 7.42 | 4.99 | 9.15 | 5.77 | 0.482 |
| Right Path Length (m) | 12.33 | 4.85 | 13.16 | 4.79 | 0.704 |
| Total Path Length (Left & Right) (m) | 19.75 | 9.52 | 22.31 | 9.72 | 0.559 |

**Amongst the participants of the two groups, that successfully completed the task, the results are presented on the following table (Table 3.3-25). 40% of residents in Group A completed the laparoscopic salpingectomy task during the post-training assessment compared to 70% of residents in Group B. One way ANOVA analysis did not present any statistically significant differences between the two groups.**

**Table 3.3-26:** Construct validity: Comparison of the post-training results between the Group-A and the Group-B among PARTICIPANTS WHO SUCCESSFULLY COMPLETED THE TASK

| **Parameters** | **Group A** | | **Group B** | | **One Way ANOVA** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |
| **Percentage of Participants who Completed the Operation (%)** | **40%** | - | **70%** | - | - |
| Time for Task Completion (min) | 16.33 | 2.87 | 12.00 | 4.65 | 0.130 |
| Time for Cautery Used (sec) | 233.92 | 61.57 | 168.64 | 95.51 | 0.255 |
| Time for Cautery Used in Air (sec) | 85.21 | 78.53 | 53.17 | 27.92 | 0.340 |
| Total Blood Loss (cc) | 379.35 | 176.81 | 377.42 | 225.90 | 0.989 |
| Percentage of Adhesions Ripped (%) | 3.62 | 5.66 | 14.00 | 30.92 | 0.531 |
| Percentage of Adhesions Lysed (%) | 100.00 | 0.00 | 100.00 | 0.00 | - |
| Left Path Length (m) | 11.74 | 4.78 | 8.94 | 6.36 | 0.467 |
| Right Path Length (m) | 16.27 | 3.37 | 12.89 | 4.91 | 0.257 |
| Total Path Length (Left & Right) (m) | 28.01 | 7.83 | 21.83 | 10.31 | 0.329 |

The comparison of the results of the pre-training test compared to the post-training test of each group **for all the participants** is given in the **Table 3.3-26**. ANOVA analysis was performed between the groups. It demonstrated non-significant differences between pre- and post-training performance for all of the analysis parameters.

**Table 3.3-27:** Difference in the pre-training as compared to the post-training test results for the Group-A and the Group-B among ALL PARTICIPANTS

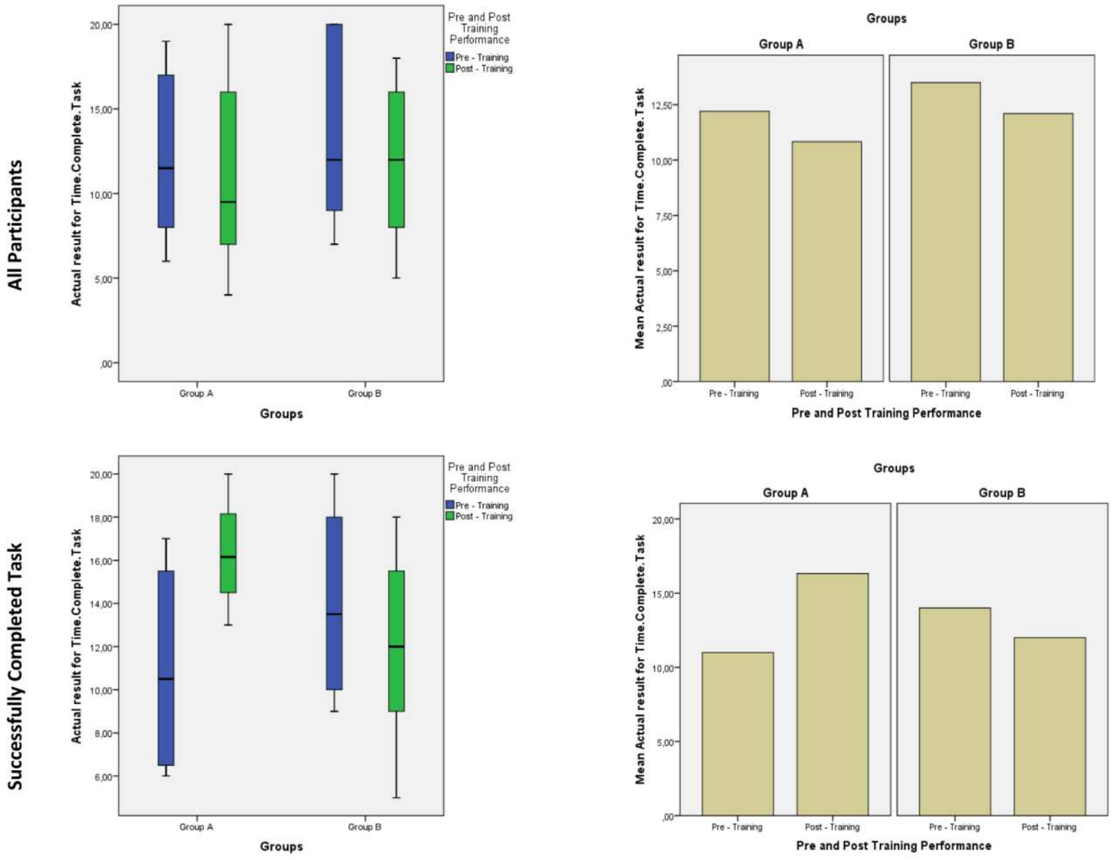
| **Parameters** | **Pre - training test** | | **Post - training test** | | **One Way ANOVA** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |
| **Group A** | | | | | |
| Time for Task Completion (min) | 12.20 | 4.87 | 10.83 | 5.30 | 0.555 |
| Time for Cautery Used (sec) | 119.66 | 71.36 | 157.79 | 90.65 | 0.310 |
| Time for Cautery Used in Air (sec) | 45.62 | 51.65 | 57.55 | 55.60 | 0.625 |
| Total Blood Loss (cc) | 585.27 | 341.84 | 405.87 | 210.23 | 0.175 |
| Percentage of Adhesions Ripped (%) | 2.6 | 1.65 | 2.846 | 3.76 | 0.852 |
| Percentage of Adhesions Lysed (%) | 94.3 | 18.02 | 97.4 | 7.54 | 0.622 |
| Left Path Length (m) | 8.21 | 4.08 | 7.42 | 4.99 | 0.702 |
| Right Path Length (m) | 12.16 | 4.95 | 12.33 | 4.85 | 0.939 |
| Total Path Length (Left & Right) (m) | 20.37 | 8.09 | 19.75 | 9.52 | 0.876 |
| **Group B** | | | | | |
| Time for Task Completion (min) | 13.50 | 5.10 | 12.10 | 4.61 | 0.528 |
| Time for Cautery Used (sec) | 131.81 | 56.47 | 159.55 | 88.46 | 0.414 |
| Time for Cautery Used in Air (sec) | 54.33 | 24.82 | 44.69 | 28.74 | 0.433 |
| Total Blood Loss (cc) | 505.77 | 279.15 | 398.05 | 211.47 | 0.344 |
| Percentage of Adhesions Ripped (%) | 14.00 | 12.29 | 12.20 | 25.57 | 0.843 |
| Percentage of Adhesions Lysed (%) | 99.40 | 0.97 | 99.80 | 0.63 | 0.288 |
| Left Path Length (m) | 7.13 | 3.69 | 9.15 | 5.77 | 0.364 |
| Right Path Length (m) | 13.20 | 4.37 | 13.16 | 4.79 | 0.986 |
| Total Path Length (Left & Right) (m) | 20.33 | 7.27 | 22.31 | 9.72 | 0.612 |

Amongst **the participants that succeeded on the laparoscopic salpingectomy task**, one way ANOVA analysis did not demonstrate statistical significance for any of the analysis parameters (**Table 3.3-27**).

**Table 3.3-28:** Difference in the pre-training as compared to the post-training test results for the Group-A and the Group-B among PARTICIPANTS WHO SUCCESSFULLY COMPLETED THE TASK

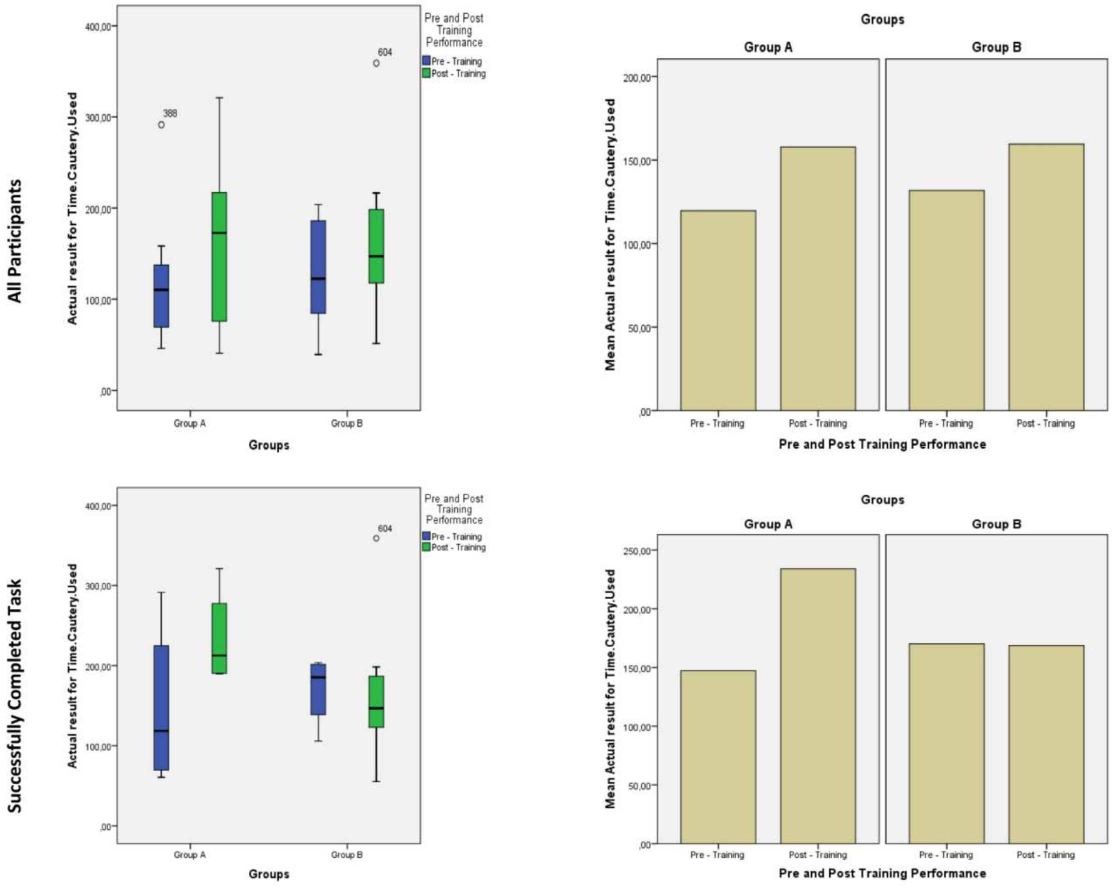
| **Parameters** | **Pre - training test** | | **Post - training test** | | **One Way ANOVA** |
|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | |
| **Group A** | | | | | |
| Percentage of Participants who Completed the Operation (%) | 40% | - | 40% | - | - |
| Time for Task Completion (min) | 11.00 | 5.35 | 16.33 | 2.87 | 0.130 |
| Time for Cautery Used (sec) | 147.23 | 105.04 | 233.92 | 61.57 | 0.204 |
| Time for Cautery Used in Air (sec) | 66.55 | 80.69 | 85.21 | 78.53 | 0.752 |
| Total Blood Loss (cc) | 612.17 | 339.16 | 379.35 | 176.81 | 0.269 |
| Percentage of Adhesions Ripped (%) | 3.00 | 1.15 | 3.62 | 5.66 | 0.838 |
| Percentage of Adhesions Lysed (%) | 100.00 | 0.00 | 100.00 | 0.00 | - |
| Left Path Length (m) | 8.28 | 5.51 | 11.74 | 4.78 | 0.379 |
| Right Path Length (m) | 12.97 | 6.52 | 16.27 | 3.37 | 0.403 |
| Total Path Length (Left & Right) (m) | 21.25 | 11.00 | 28.01 | 7.83 | 0.355 |
| | | | | | |
| **Group B** | | | | | |
| Percentage of Participants who Completed the Operation (%) | 40% | - | 70% | - | - |
| Time for Task Completion (min) | 14.00 | 4.97 | 12.00 | 4.65 | 0.520 |
| Time for Cautery Used (sec) | 170.08 | 45.12 | 168.64 | 95.51 | 0.978 |
| Time for Cautery Used in Air (sec) | 64.46 | 12.45 | 53.17 | 27.92 | 0.470 |
| Total Blood Loss (cc) | 542.31 | 307.88 | 377.42 | 225.90 | 0.331 |
| Percentage of Adhesions Ripped (%) | 21.00 | 16.69 | 14.00 | 30.92 | 0.689 |
| Percentage of Adhesions Lysed (%) | 100.00 | 0.00 | 100.00 | 0.00 | - |
| Left Path Length (m) | 8.11 | 3.91 | 8.94 | 6.36 | 0.821 |
| Right Path Length (m) | 15.36 | 4.16 | 12.89 | 4.91 | 0.421 |
| Total Path Length (Left & Right) (m) | 23.47 | 6.70 | 21.83 | 10.31 | 0.783 |

**Figure 3.3-31i:** Box plot and bar-graph comparing the Total Time taken (in minutes) in Group-A and in Group-B between pre- and post-test assessment among all participants or the participants who successfully completed the operation



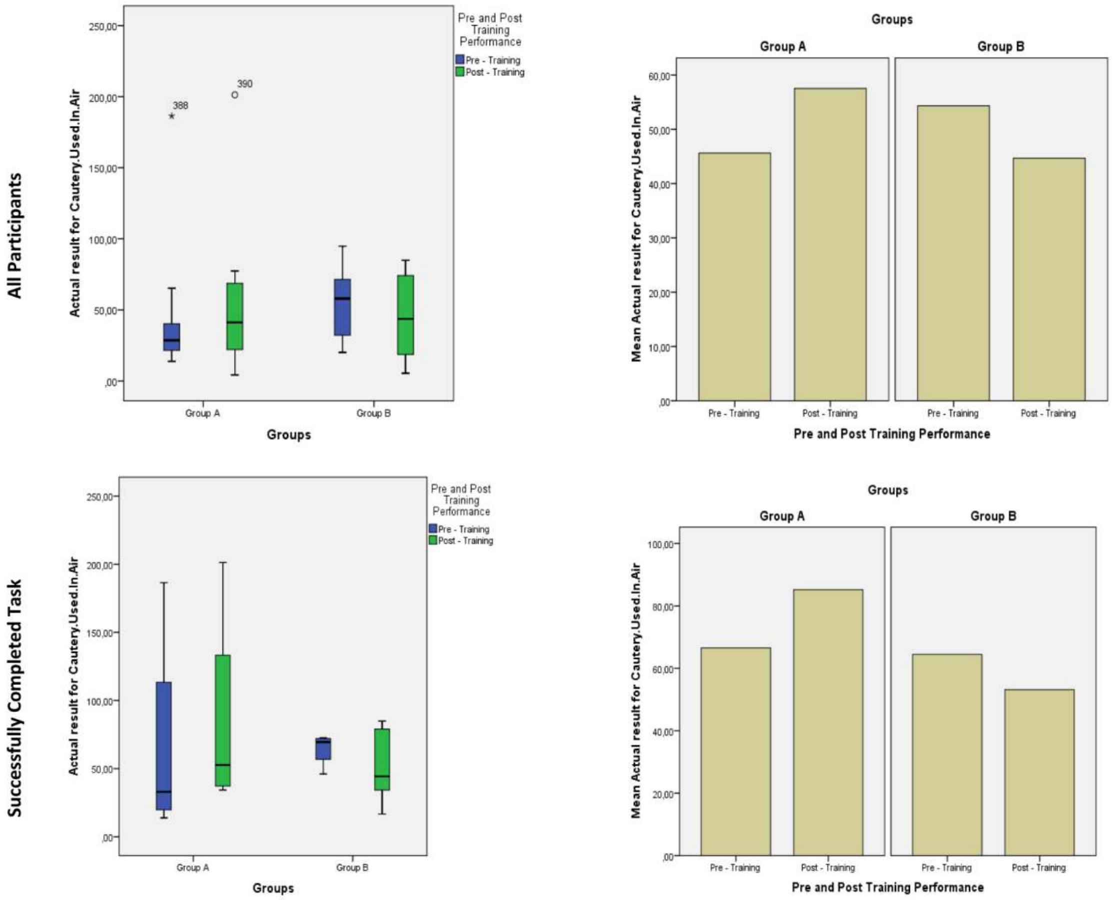
- **All Participants: The median of Group-A of the time to complete the task has reduced during the post-training as compared to pre-training**. On the other hand, for Group-B, the medial remained roughly the same.
- **Successfully Completed the Operation: The median time of completion has risen for Group A and reduced for Group B on post-training performance**.

**Figure 3.3-31ii:** Box plot and bar-graph comparing the Time for Cautery Used in Group-A and in Group-B between pre- and post-test assessment (in seconds) among all participants or the participants who successfully completed the operation



- **<u>All Participants:</u>** The median for Cautery Used records an increase on the post-training for both groups of participants.
- **<u>Successfully Completed the Operation:</u>** The same trend holds among the participants of Group A, while for Group-B, on post-training, the median has shifted downwards.

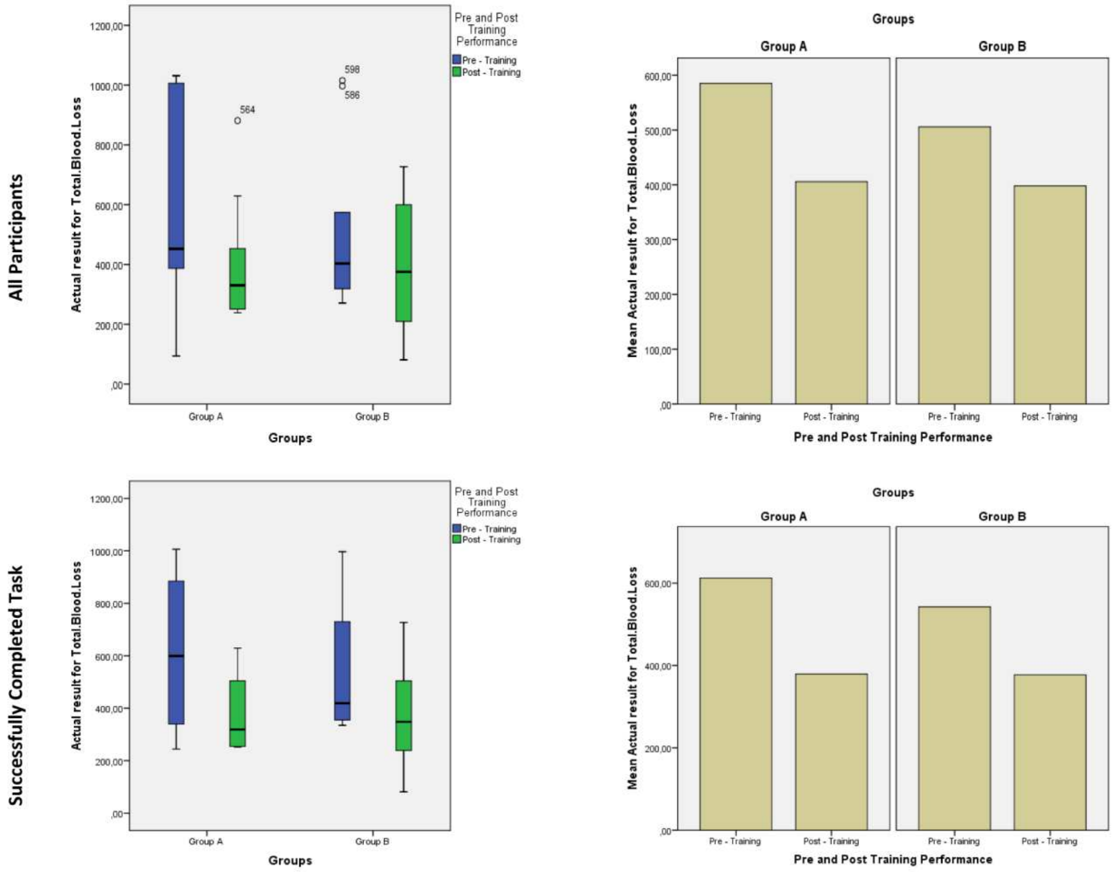
**Figure 3.3-32:** Box plot and bar-graph comparing the Time for Cautery Used in Air in Group-A and in Group-B between pre- and post-test assessment (in seconds) among all participants or the participants who successfully completed the operation



- **<u>All Participants:</u>** The median for Cautery used in air increases for Group-A on post-training while reduces for Group B.

- **<u>Successfully Completed the Operation:</u>** The median increases for Group-A, and decreases for Group-B.

**Figure 3.3-33:** Box plot and bar-graph comparing the Blood Loss in Group-A and in Group-B between pre- and post-test assessment (in cc) among all participants or the participants who successfully completed the operation



- **<u>All Participants:</u>** The median for blood loss demonstrates a reduction on the post-training session, for both groups of participants.

- **<u>Successfully Completed the Task:</u>** The same trend as in the previous case of all participants.

**Figure 3.3-34:** Box plot and bar-graph comparing the Percentage of Adhesion Ripped in Group-A and in Group-B between pre- and post-test assessment among all participants or the participants who successfully completed the operation

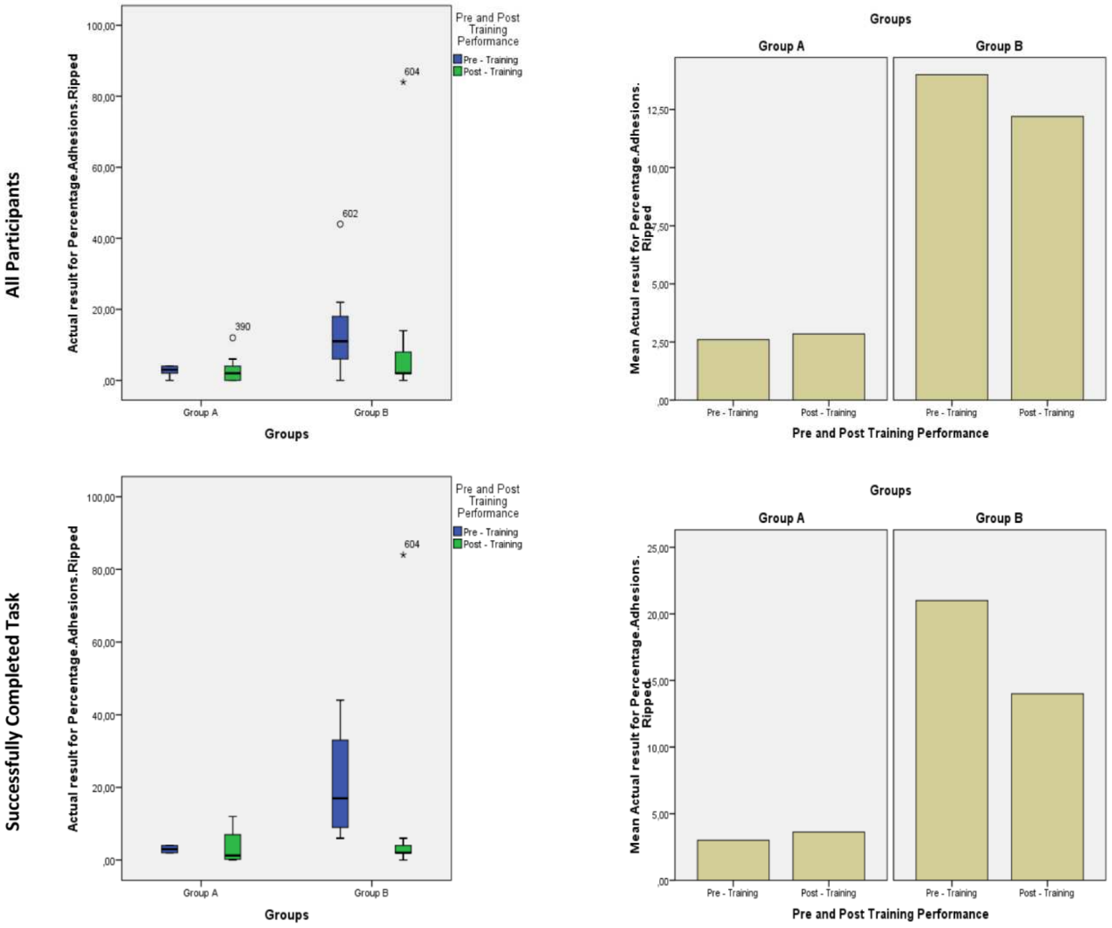
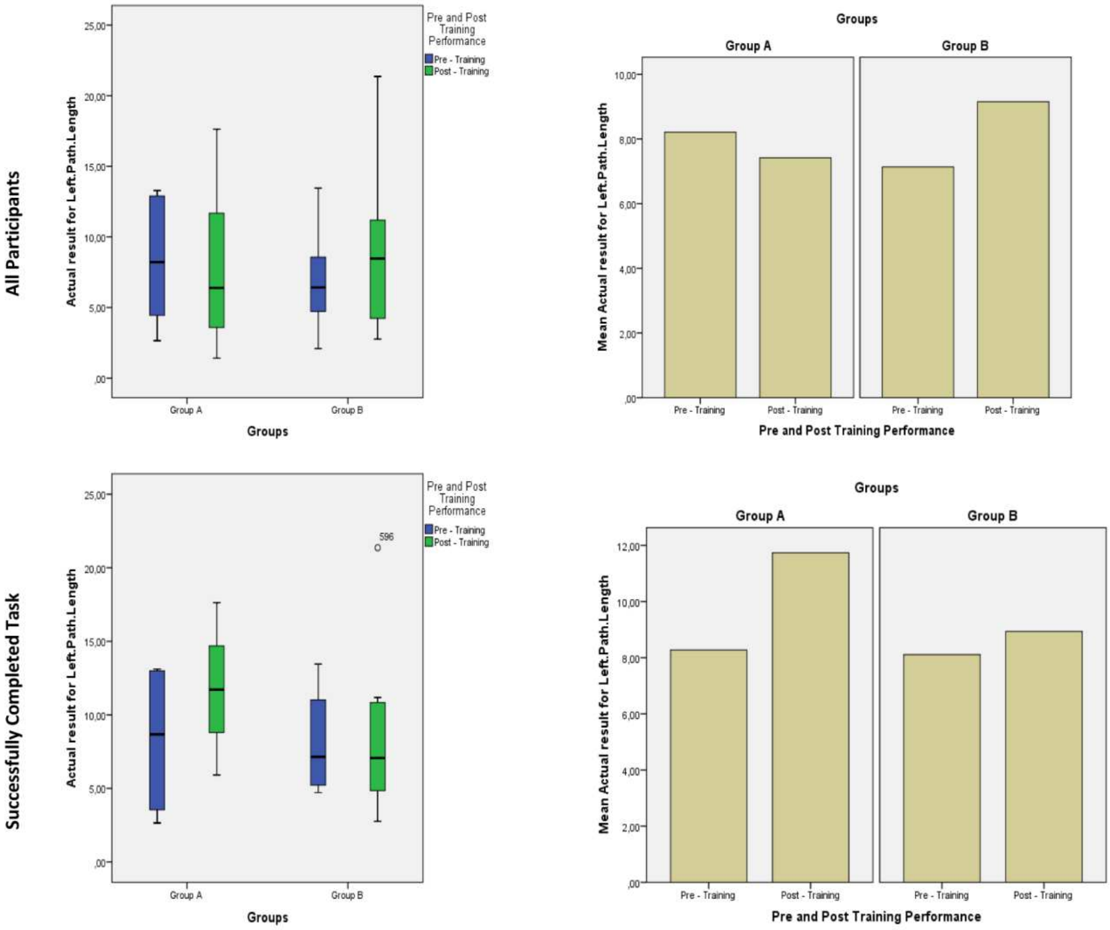


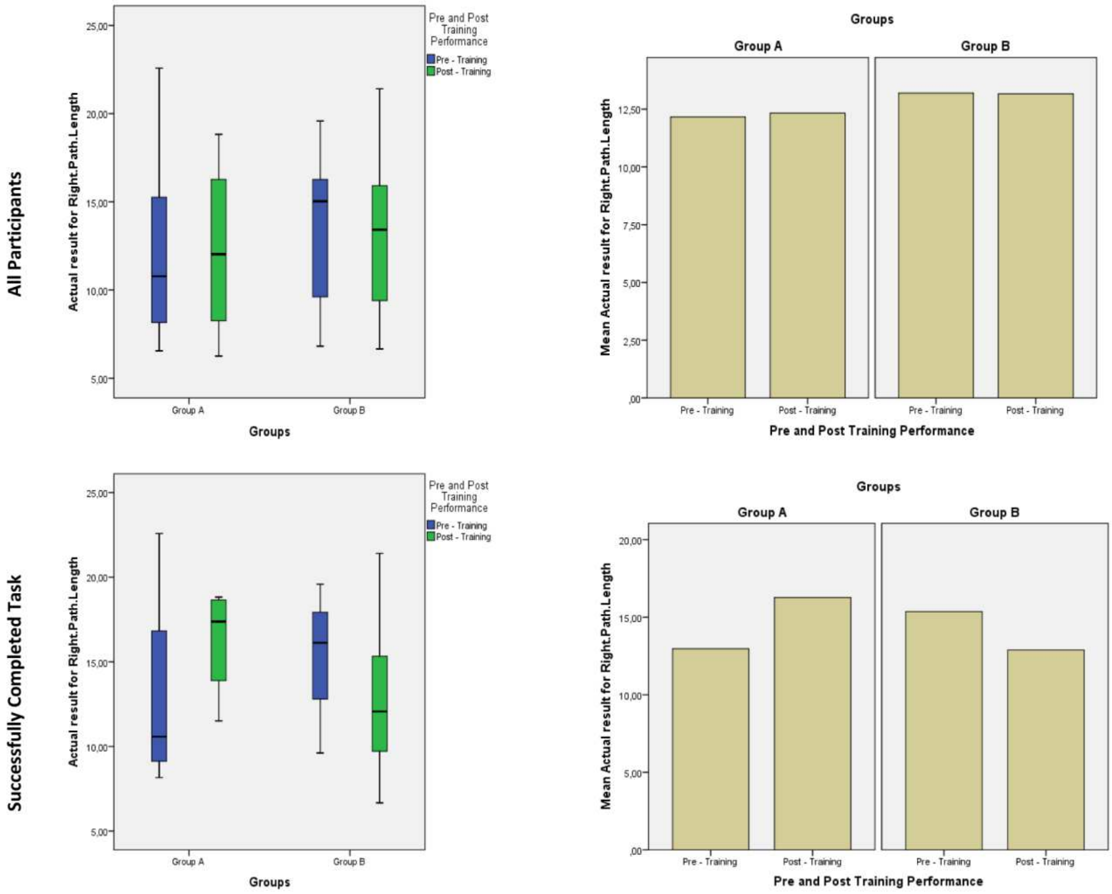
**Figure 3.3-35:** Box plot and bar-graph comparing the Left Path Length (in meters) in Group-A and in Group-B between pre- and post-test assessment (in mm) among all participants or the participants who successfully completed the operation



- **All Participants:** The median of Group-A decreased during the post-training, while for Group-B, it carved the opposite direction.

- **Successfully Completed the Task:** The median of Group-A increased during the post-training, while for Group-B, it remained at the same level.

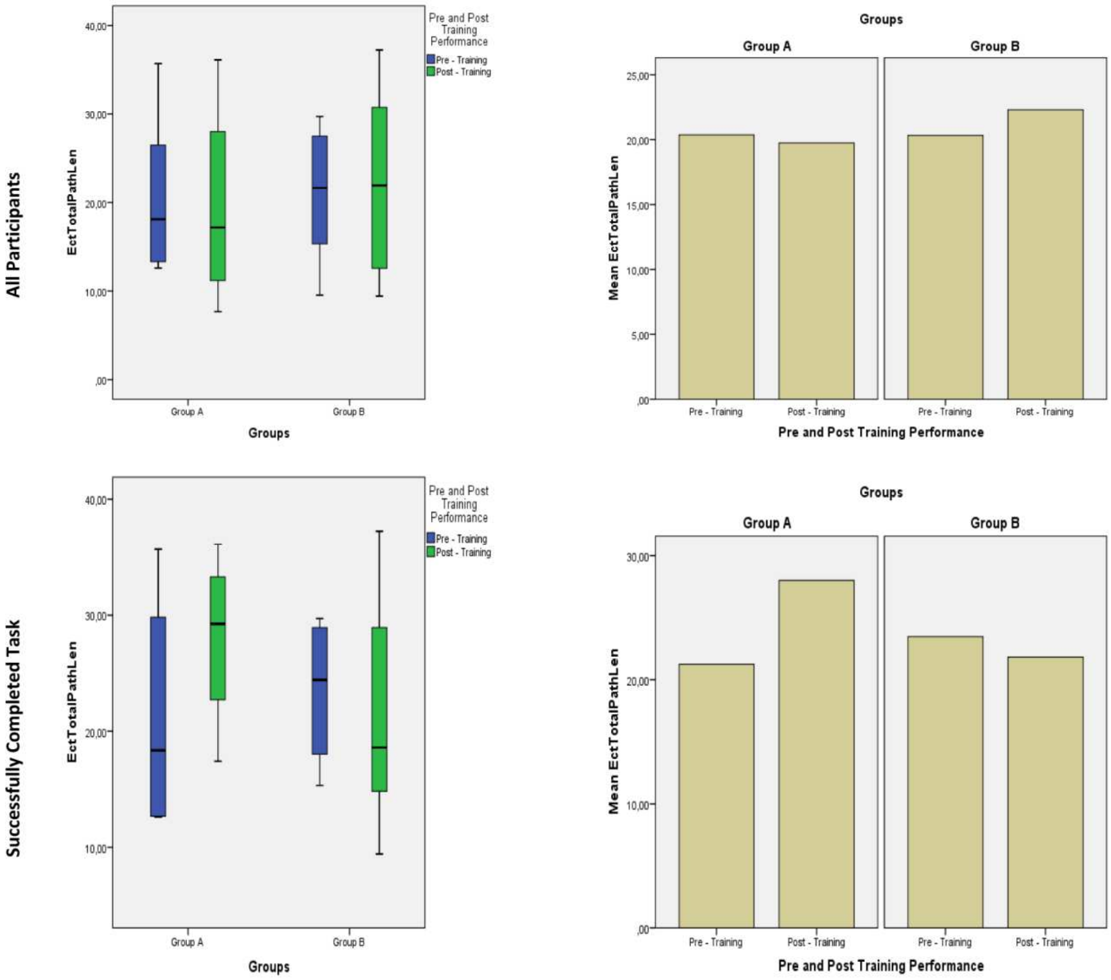
**Figure 3.3-36:** Box plot and bar-graph comparing the Right Path Length (in meters) in Group-A and in Group-B between pre- and post-test assessment (in mm) among all participants or the participants who successfully completed the operation



- **<u>All Participants:</u>** The median of Group-A increased during the post-training, while for Group-B, it carved the opposite direction.

- **<u>Successfully Completed the Task:</u>** The median of Group-A increased during the post-training, while for Group-B, it decreased.

**Figure 3.3-37:** Box plot and bar-graph comparing the Total Path Length (in meters) in Group-A and in Group-B between pre- and post-test assessment (in mm) among all participants or the participants who successfully completed the operation



- **<u>All Participants:</u>** The median for both groups, on post-training, presents incremental deviation in comparison to pre-training.

- **<u>Successfully Completed the Task:</u>** The total path length demonstrates a noticeable increase for Group-A during the post-training, when the exact opposite occurs for Group-B.

## 3.3.5. Correlation & Linear Regression Analysis of Analysis Parameters for Salpingectomy Task

### 3.3.5.1. Actual Result for Time of Task Completion

The **Table 3.3-28** below summarizes the Spearman's correlation analysis of time to complete test and the rest analysis parameters regarding salpingectomy, at the pre and post training session. Analysis is focused on all of the participants that participated in the task. As become evident by the **Table 3.3-28** below, “Time to complete the task” correlates significantly with Time for Cautery Used (and Time for Cautery Used in Air) and with the path lengths during the pre- and post-training assessment as well.

**Table 3.3-29: Spearman's Correlation Analysis between Time to Complete the Task and the other analysis parameters, at the pre-training performance versus post-training performance, by group, among all participants**

| **Session** | | **Time for Cautery Used** | **Time for Cautery Used In Air** | **Total Blood Loss** | **Percentage of Adhesions Ripped** | **Percentage of Adhesions Lysed** | **Left Path Length** | **Right Path Length** | **Total Path Length** |
|---|---|---|---|---|---|---|---|---|---|
| **Pre Training** | **Coef** | 0.732** | 0.666** | -0.131 | 0.123 | 0.081 | 0,851** | 0.764** | 0.908** |
| | **Sig** | 0.00 | 0.001 | 0.581 | 0.606 | 0.733 | 0.000 | 0.000 | 0.000 |
| Pre Training Group A | Coef | 0.748* | 0.559 | -0.024 | -0.201 | 0.175 | 0,857** | 0.766** | 0.960** |
| | Sig | 0.013 | 0,093 | 0.947 | 0.577 | 0.629 | 0,002 | 0,01 | 0.000 |
| Pre Training Group B | Coef | 0.628 | 0.739* | -0.018 | -0.025 | 0.077 | ,899** | 0.796** | 0.935** |
| | Sig | 0.052 | 0.015 | 0.96 | 0.946 | 0.832 | 0.000 | 0.006 | 0.000 |
| **Post Training** | **Coef** | 0.751** | 0.462* | -0.094 | 0.212 | 0.067 | 0,925** | 0.807** | 0.939** |
| | **Sig** | 0.000 | 0.04 | 0.693 | 0.37 | 0.78 | 0.000 | 0.000 | 0.000 |
| Post Training Group A | Coef | 0.673* | 0.406 | -0.212 | -0.292 | 0.32 | 0.915** | 0.842** | 0.927** |
| | Sig | 0.033 | 0.244 | 0.556 | 0.413 | 0.367 | 0.000 | 0,002 | 0.000 |
| Post Training Group B | Coef | 0.915** | 0.439 | 0.037 | 0.735* | -0.467 | 0.982** | 0.823** | 0.939** |
| | Sig | 0.000 | 0.204 | 0.92 | 0.015 | 0.174 | 0.000 | 0.003 | 0.000 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

## Scatter plot of Completion Time versus Economy of Motions among all participants

Focusing on the time to complete the task and the economy of motions, **most of the participants, on the pre-training, appear to be concentrated to the lower-left portion of the graph**. On the other hand, **on the post-training session the participants of the two groups appear to have sifted upwards and to the right of the graph**. K-means cluster analysis is significant (p=0.000) in both pre- and post-training and it shows two distinct clusters.

**Figure 3.3-38: Scatter plot of Completion Time versus Economy of Motions, for participants in Group A and Group B, during Pre - Training**

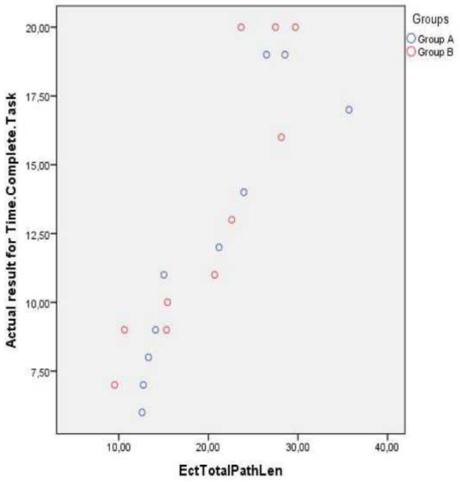


**Figure 3.3-39: Scatter plot of Completion Time versus Economy of Motions, for participants in Group A and Group B, during Post - Training**

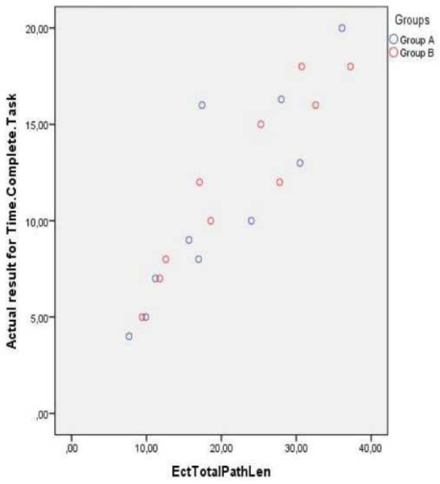


**Figure 3.3-40: K-Means cluster of Completion time versus Economy of Motions, during Pre-Training**

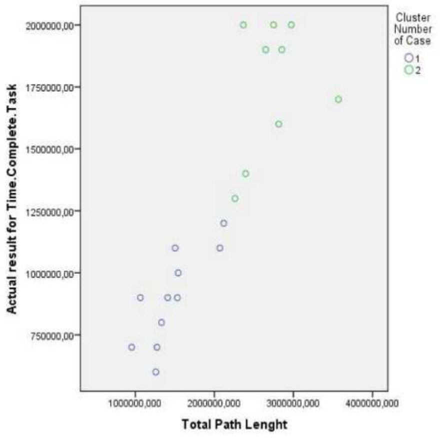


**Figure 3.3-41: K-Means cluster of Completion time versus Economy of Motions, during Post-Training**

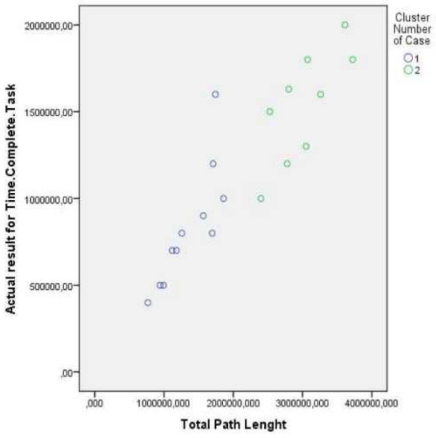
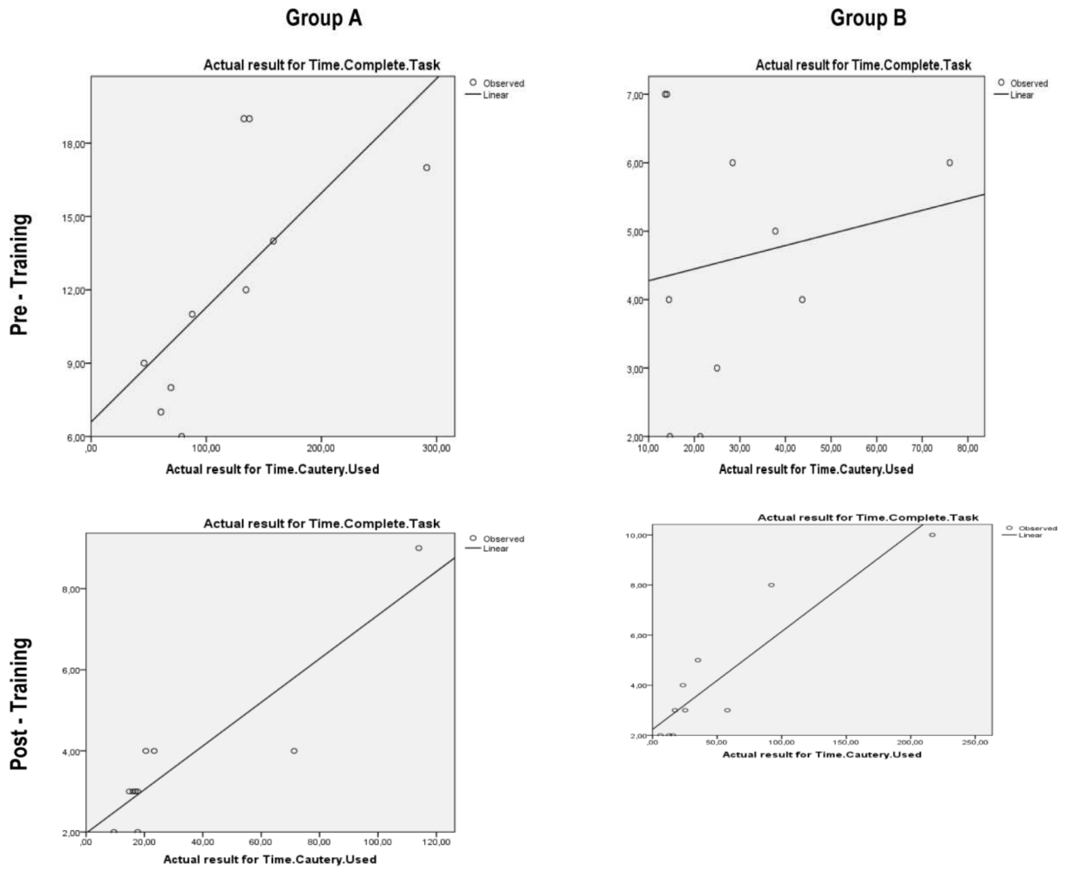


**Figure 3.3-42:** Linear Regression between Time to complete the Task (in minutes) and Time for Cautery Used (in seconds) among all participants

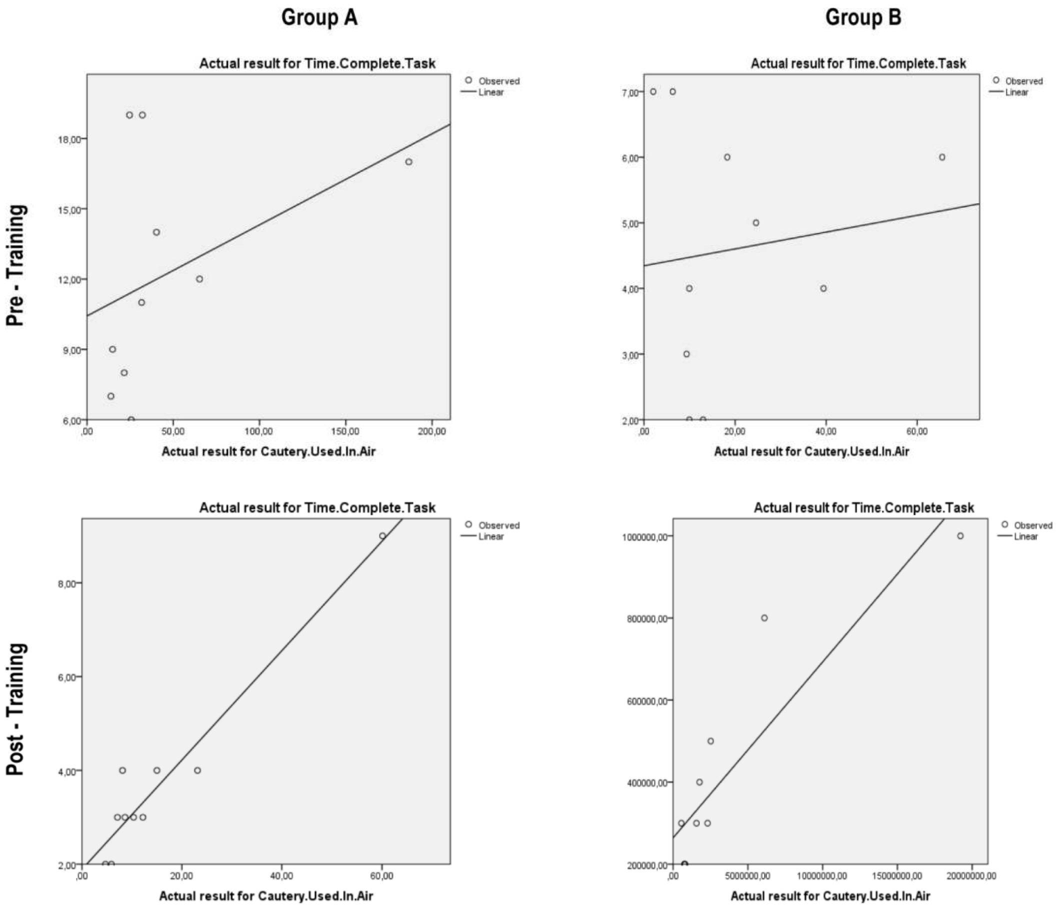


### Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.471 | 0.028 |
| | B | 0.031 | 0.624 |
| **Post-Training** | A | 0.814 | 0.000 |
| | B | 0.828 | 0.000 |

**The models are significant on the post-training sessions**, and the pre-training for Group A.

**Figure 3.3-43:** Linear Regression between Time to Complete the Task (in minutes) and Time for Cautery Used in Air (in seconds) among all participants

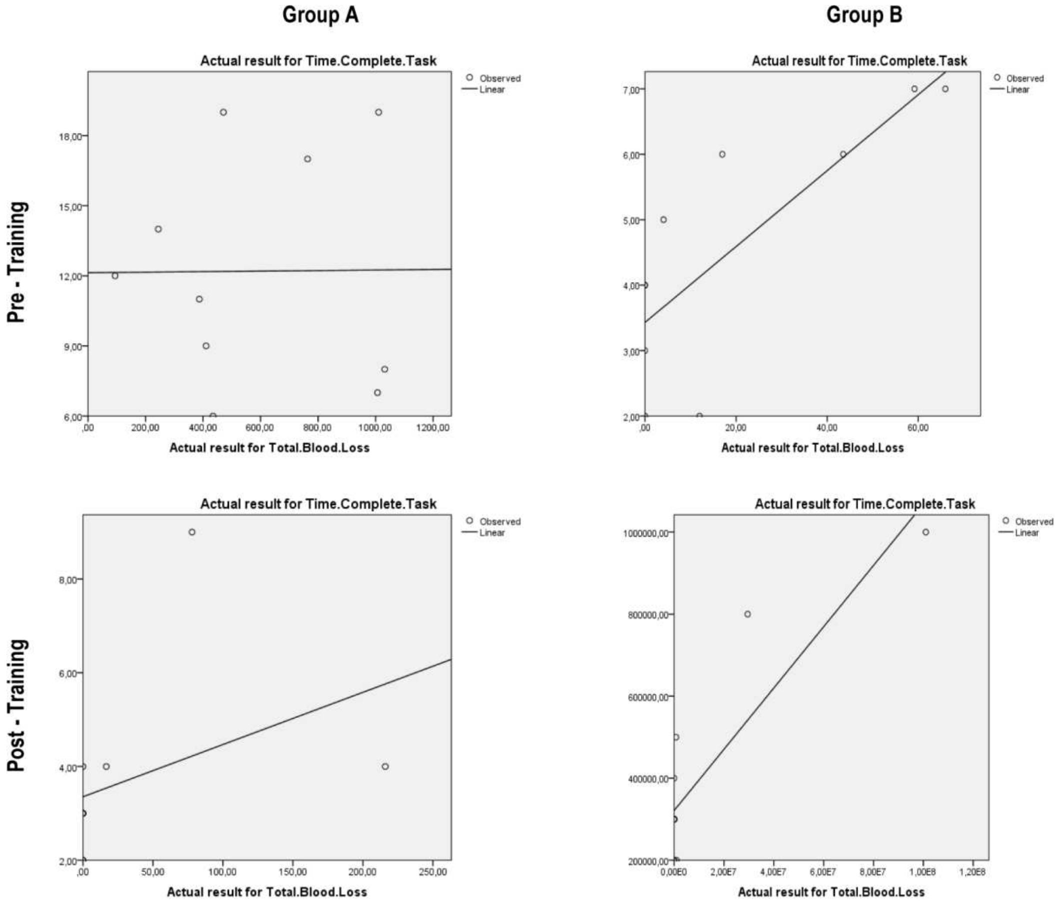


### Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.170 | 0.237 |
| | B | 0.170 | 0.720 |
| **Post-Training** | A | 0.929 | 0.000 |
| | B | 0.799 | 0.000 |

**The models are significant only on the post-training sessions**.

**Figure 3.3-44:** Linear Regression between Time to Complete the Task (in minutes) and Blood Loss (in cubic centimeters) among all participants

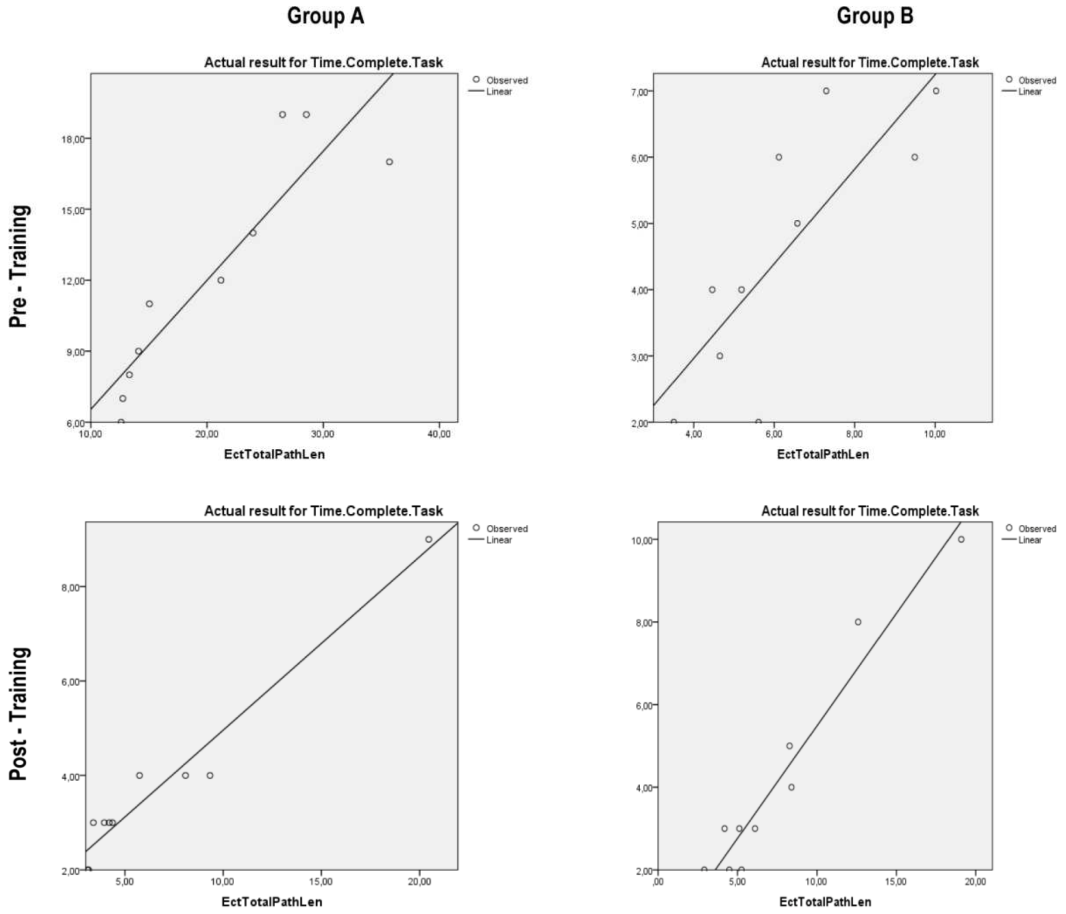


## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| Pre-Training | A | 0.000 | 0.983 |
| | B | 0.637 | 0.006 |
| Post-Training | A | 0.149 | 0.271 |
| | B | 0.769 | 0.001 |

**The models are significant only on for Group-B, for both of the sessions.**

**Figure 3.3-45:** Linear Regression between Time to Complete the Task (in minutes) and Total Path Length (in meters) among all participants



## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.819 | 0.000 |
| | B | 0.641 | 0.005 |
| **Post-Training** | A | 0.953 | 0.000 |
| | B | 0.944 | 0.000 |

**All models are statistically significant**.

### 3.3.5.2. Actual Result for Time for Cautery Used

The **Table 3.3-29** below summarizes the Spearman's correlation analysis of Time for Cautery Used and the rest analysis parameters regarding salpingectomy, at the pre- and post-training session among all participants.

**Table 3.3-30: Spearman's Correlation Analysis between Time for Cautery Used and the other analysis parameters, at the pre-training performance versus post-training performance, by group among all participants**

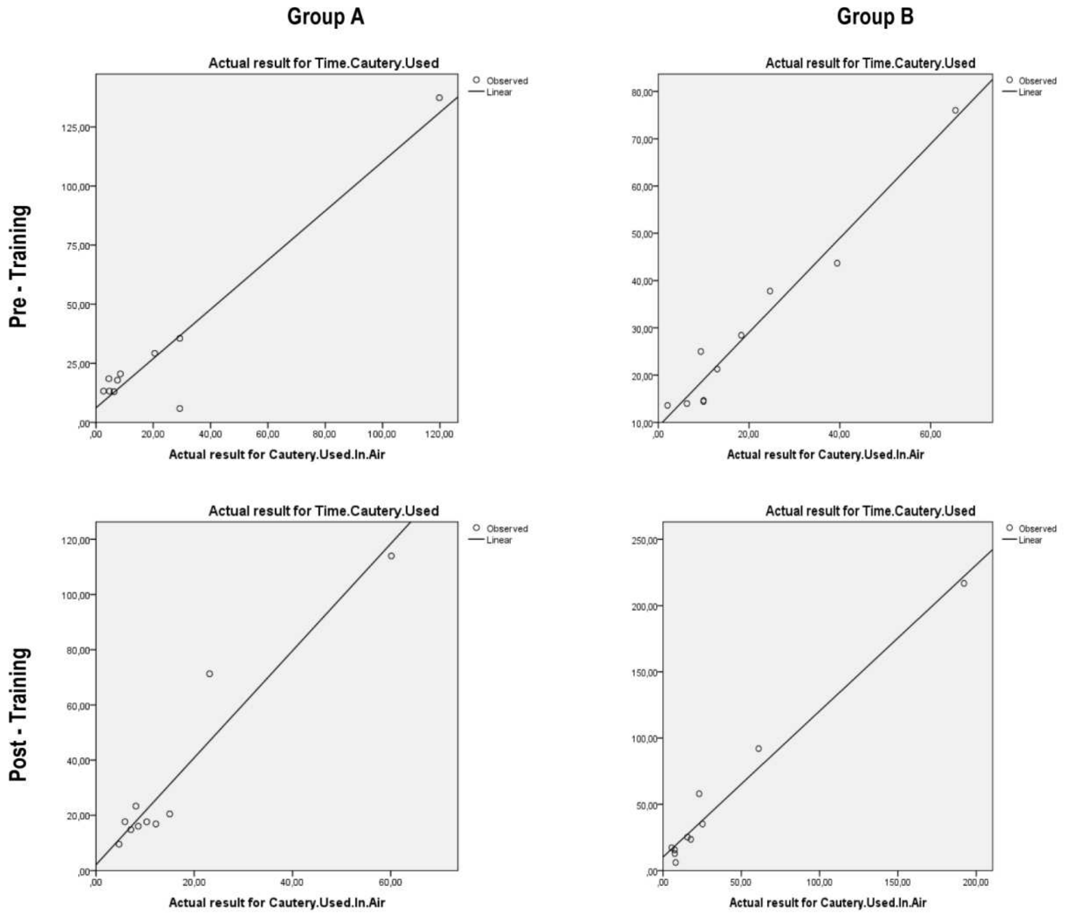
| Session | | Time for Cautery Used In Air | Total Blood Loss | Percentage of Adhesions Ripped | Percentage of Adhesions Lysed | Left Path Length | Right Path Length | Total Path Length |
|---|---|---|---|---|---|---|---|---|
| Pre Training | Coef | 0.853** | -0.003 | 0.264 | 0.324 | 0.665** | 0.824** | 0,823** |
| | Sig | 0.000 | 0.99 | 0.261 | 0.164 | 0.001 | 0.000 | 0.000 |
| Pre Training Group A | Coef | 0.842** | -0.176 | -0.092 | 0.522 | 0.842** | 0.782** | 0,830** |
| | Sig | 0.002 | 0.627 | 0.8 | 0.122 | 0.002 | 0.008 | 0.003 |
| Pre Training Group B | Coef | 0.842** | 0.333 | 0.389 | 0.418 | 0.527 | 0.766** | 0.697* |
| | Sig | 0.002 | 0.347 | 0.266 | 0.23 | 0.117 | 0.01 | 0.025 |
| Post Training | Coef | 0.689** | 0.188 | 0.214 | 0.226 | 0.710** | 0.848** | 0.780** |
| | Sig | 0.001 | 0.427 | 0.365 | 0.337 | 0.000 | 0.000 | 0.000 |
| Post Training Group A | Coef | 0.758* | 0.382 | -0.118 | 0.528 | 0.612 | 0.830** | 0.770** |
| | Sig | 0,011 | 0.276 | 0.745 | 0.117 | 0.06 | 0.003 | 0.009 |
| Post Training Group B | Coef | 0.539 | -0.115 | 0.756* | -0.406 | 0.879** | 0.891** | 0.879** |
| | Sig | 0.108 | 0.751 | 0.011 | 0.244 | 0.001 | 0.001 | 0.001 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

**The Time for Cautery Used correlates significantly with the Time for Cautery Used in Air and with the Path Lengths**.

**Figure 3.3-46: Linear Regression between the Time for Cautery Used (in seconds) and Time for Cautery Used In Air (in seconds)**

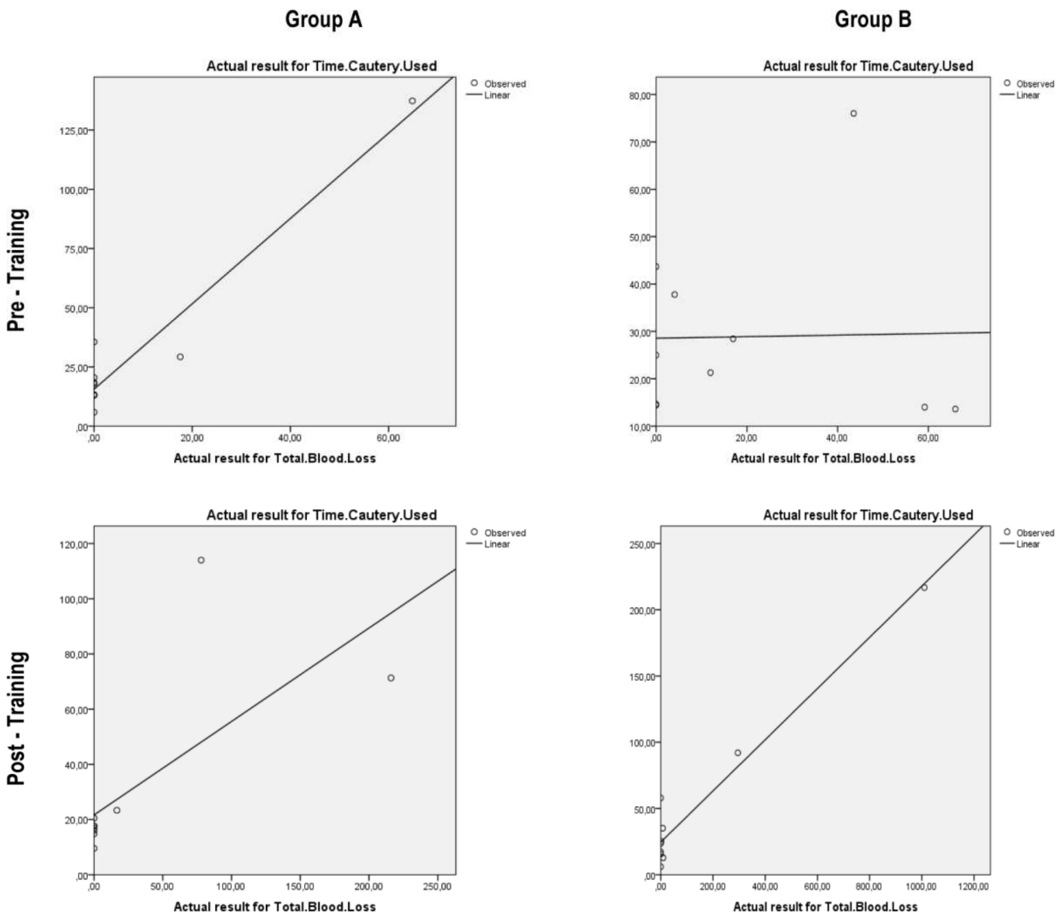


## Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| Pre-Training | A | 0.916 | 0.000 |
| | B | 0.961 | 0.000 |
| Post-Training | A | 0.913 | 0.000 |
| | B | 0.973 | 0.000 |

**All models are statistically significant and have a very good fit.**

**Figure 3.3-47:** Linear Regression between the Time for Cautery Used (in seconds) and Blood Loss (in cubic centimeters) among all participants

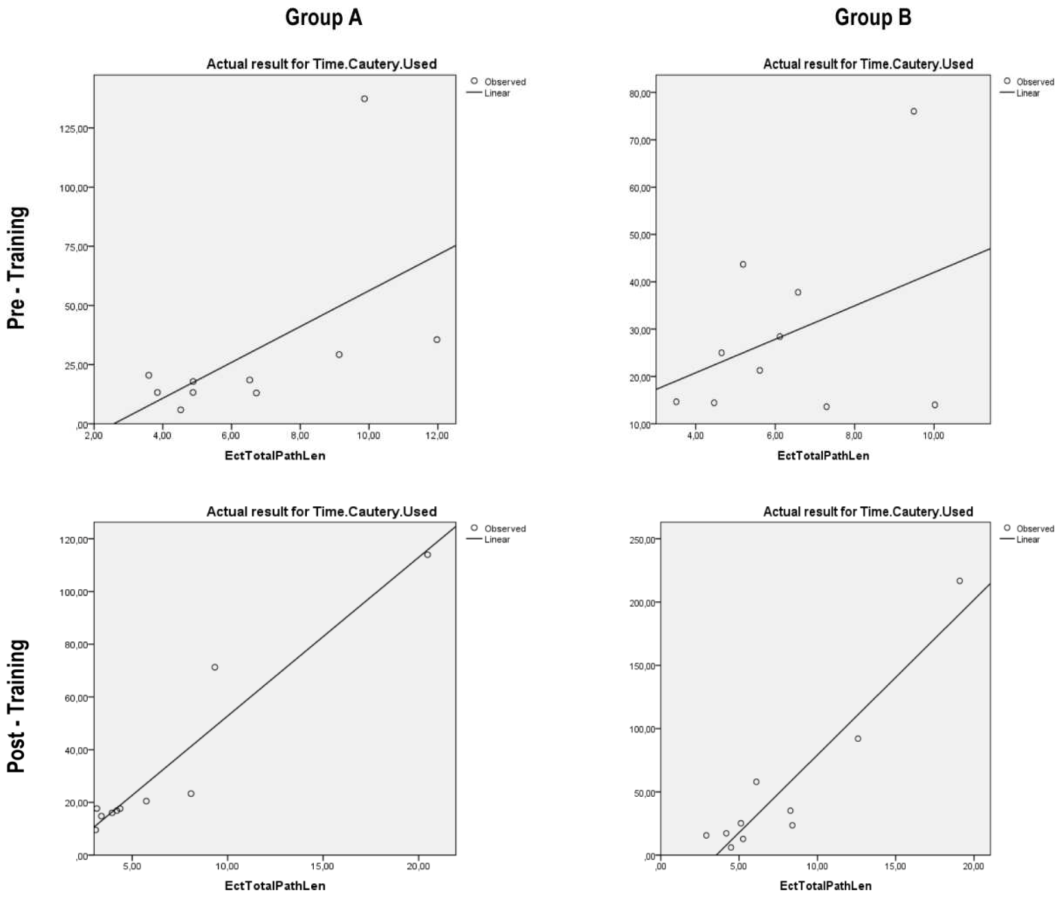


Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| Pre-Training | A | 0.933 | 0.000 |
| | B | 0.000 | 0.962 |
| Post-Training | A | 0.489 | 0.024 |
| | B | 0.946 | 0.000 |

**All models are statistically significant, except for Group-B, on pre-training.**

**Figure 3.3-48:** Linear Regression between the Time for Cautery Used (in seconds) and the Total Path Length (in meters) among all participants



Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| **Pre-Training** | A | 0.313 | 0.093 |
| | B | 0.147 | 0.274 |
| **Post-Training** | A | 0.909 | 0.000 |
| | B | 0.882 | 0.000 |

**The models are statistically significant and have a very good fit, on the post-training session.**

### 3.3.5.3. Actual Result for Blood Loss

The **Table 3.3-30** below summarizes the Spearman's correlation analysis for Blood Loss (in cc) and the rest analysis parameters regarding salpingectomy, at the pre and post training session.

**Table 3.3-31: Spearman's Correlation Analysis between the Blood Loss (in cubic centimeters) and the other analysis parameters, at the pre-training performance versus post-training performance, by group among all participants**

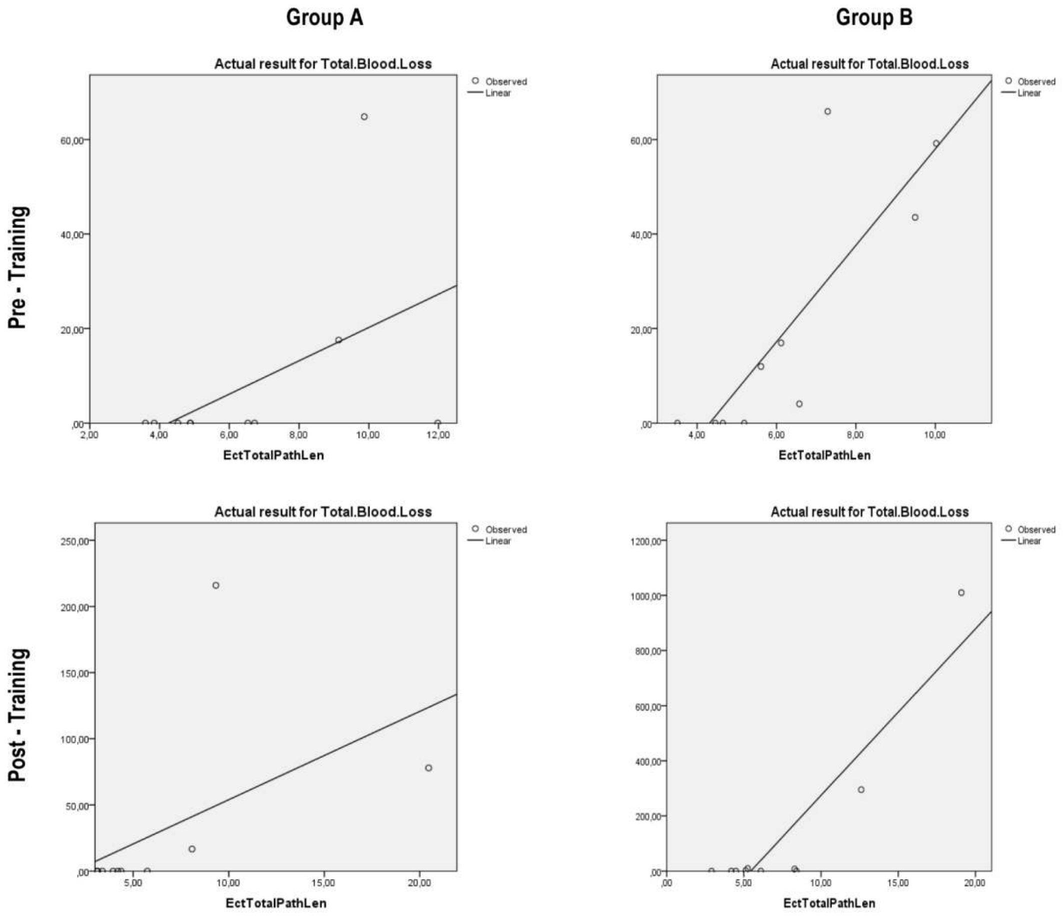
| **Session** | | **Percentage of Adhesions Ripped** | **Percentage of Adhesions Lysed** | **Left Path Length** | **Right Path Length** | **Total Path Length** |
|---|---|---|---|---|---|---|
| Pre Training | Coef | 0.196 | 0.437 | -0.164 | 0.244 | 0.047 |
| | Sig | 0.407 | 0.054 | 0.490 | 0.300 | 0.845 |
| Pre Training A | Coef | 0.368 | 0.174 | -0.188 | 0.236 | -0.018 |
| | Sig | 0.295 | 0.631 | 0.603 | 0.511 | 0.96 |
| Pre Training B | Coef | 0.638* | 0.798** | 0.067 | 0.237 | 0.176 |
| | Sig | 0.047 | 0.006 | 0.855 | 0.51 | 0.627 |
| Post Training | Coef | 0.064 | -0.038 | 0.018 | -0.06 | -0.009 |
| | Sig | 0.789 | 0.875 | 0.94 | 0.801 | 0.97 |
| Post Training A | Coef | 0.304 | 0.138 | -0.079 | 0.139 | -0.006 |
| | Sig | 0.392 | 0.703 | 0.829 | 0.701 | 0.987 |
| Post Training B | Coef | -0.162 | -0.174 | 0.103 | -0.236 | 0.006 |
| | Sig | 0.656 | 0.631 | 0.777 | 0.511 | 0.987 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

**The blood loss correlates significantly with the percentage of adhesion ripped and the percentage of adhesions lysed, although that occurs only on the pre-training session for the Group-B**.

**Figure 3.3-49a: Linear Regression between Blood loss (in cubic centimeters) and Total Path Length (in meters) among all participants**



### Linear Models Summary

| Pre/Post Training | Groups | R-Square | Statistical Significance |
|---|---|---|---|
| Pre-Training | A | 0.236 | 0.154 |
| | B | 0.693 | 0.003 |
| Post-Training | A | 0.262 | 0.130 |
| | B | 0.842 | 0.000 |

**The models are statistically significant for Group-B.**

At this section, the template that has been forwarded calls for a logistic regression-analysis. This analysis cannot be performed because, as it is stated in the template, the depended variable is not a categorical one. We remind that such analysis is feasible only when the depended variable of the analysis is a categorical one. As Table 3.3-31 presents, gender does not seem to impact the performance of participants on Salpingectomy neither on pre- nor on post-training. Statistical tests do not show any significant difference for any of the analysis parameters.

**Table 3.3-32: Pre- & Post-training results for analysis parameters of Salpingectomy and Gender**

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Male | | Female | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 13.09 | 5.52 | 12.56 | 4.33 | 0.815 | 0.941 |
| Time Cautery Used | 122.69 | 52.42 | 129.46 | 77.11 | 0.818 | 0.941 |
| Cautery Used in Air | 43.80 | 24.95 | 57.52 | 53.36 | 0.457 | 1.000 |
| Blood Loss | 508.68 | 269.72 | 590.55 | 357.76 | 0.567 | 0.941 |
| Adhesions Ripped | 8.55 | 12.17 | 9.00 | 8.28 | 0.928 | 0.840 |
| Adhesions Lysed | 99.82 | 0.60 | 93.22 | 18.85 | 0.325 | 0.370 |
| Left Path Length | 7.51 | 4.14 | 7.86 | 3.64 | 0.847 | 0.824 |
| Right Path Length | 12.39 | 3.91 | 13.04 | 5.51 | 0.761 | 1.000 |
| Total Path Length | 19.90 | 7.03 | 20.90 | 8.41 | 0.776 | 0.882 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Male | | Female | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 11.75 | 5.30 | 11.11 | 4.590 | 0.778 | 0.882 |
| Time Cautery Used | 169.96 | 89.14 | 144.87 | 87.90 | 0.537 | 0.503 |
| Cautery Used in Air | 48.74 | 26.48 | 54.02 | 60.14 | 0.796 | 0.656 |
| Blood Loss | 365.67 | 221.36 | 446.31 | 186.54 | 0.397 | 0.331 |
| Adhesions Ripped | 11.16 | 27.37 | 5.56 | 4.88 | 0.554 | 0.297 |
| Adhesions Lysed | 100.00 | 0.000 | 96.89 | 7.88 | 0.270 | 0.230 |
| Left Path Length | 7.46 | 4.860 | 9.29 | 5.97 | 0.460 | 0.503 |
| Right Path Length | 12.57 | 4.820 | 12.96 | 4.82 | 0.860 | 0.882 |
| Total Path Length | 20.03 | 9.370 | 22.25 | 9.98 | 0.615 | 0.710 |

**Bringing in focus the video games users, there is only a statistical significance for right path length on post-training assessment (Table 3.3-32).**

**Table 3.3-33: Pre- & Post-training results for analysis parameters of Salpingectomy and Video Games Users**

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Video Games Users | | Video Games Not-Users | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 12.63 | 6.28 | 13.00 | 4.05 | 0.872 | 0.792 |
| Time Cautery Used | 95.63 | 52.50 | 145.81 | 63.17 | 0.080 | 0.082 |
| Cautery Used in Air | 41.16 | 28.47 | 55.86 | 45.95 | 0.432 | 0.521 |
| Blood Loss | 489.38 | 234.47 | 582.94 | 351.33 | 0.484 | 0.910 |
| Adhesions Ripped | 5.25 | 2.82 | 11.27 | 13.18 | 0.169 | 0.657 |
| Adhesions Lysed | 92.63 | 20.06 | 99.67 | 0.78 | 0.354 | 0.734 |
| Left Path Length | 7.20 | 4.22 | 7.98 | 3.70 | 0.669 | 0,678 |
| Right Path Length | 10.98 | 4.10 | 13.81 | 4.69 | 0.182 | 0.208 |
| Total Path Length | 18.18 | 7.61 | 21.79 | 7.36 | 0.303 | 0.305 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Video Games Users | | Video Games Not-Users | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 9.13 | 4.42 | 13.03 | 4.69 | 0.079 | 0.098 |
| Time for Cautery Used | 114.47 | 64.89 | 188.14 | 89.89 | 0.062 | 0.057 |
| Time for Cautery Used in Air | 40.24 | 26.23 | 58.37 | 51.95 | 0.376 | 0.521 |
| Blood Loss | 426.56 | 286.36 | 385.56 | 140.92 | 0.716 | 0.851 |
| Adhesions Ripped | 3.00 | 2.45 | 11.04 | 23.42 | 0.421 | 0.616 |
| Adhesions Lysed | 97.00 | 8.49 | 99.67 | 0.78 | 0.405 | 0.970 |
| Left Path Length | 6.67 | 6.30 | 9,36 | 4.53 | 0.280 | 0.115 |
| Right Path Length | 10.06 | 3.27 | 14.54 | 4.78 | 0.033 | 0.039 |
| Total Path Length | 16.73 | 9.19 | 23.89 | 8.85 | 0.098 | 0.098 |

Regarding the **players of musical instruments**, there are no statistical significant differences neither on pre- nor on post-training performance between the two groups (**Table 3.3-33**).

### Table 3.3-34: Pre- & Post-training results for analysis parameters of Salpingectomy and Players of Musical Instruments

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Players of Musical Instruments | | Not Players of Musical Instruments | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 13.00 | 6.07 | 12.79 | 4.58 | 0.931 | 0.904 |
| Time Cautery Used | 127.75 | 56.35 | 124.87 | 67.57 | 0.928 | 0.904 |
| Cautery Used in Air | 48.92 | 24.30 | 50.43 | 45.55 | 0.940 | 0.718 |
| Blood Loss | 559.45 | 371.41 | 539.55 | 289.99 | 0.898 | 0.904 |
| Adhesions Ripped | 6.67 | 6.53 | 9.69 | 11.94 | 0.572 | 0.765 |
| Adhesions Lysed | 100.00 | 0.00 | 95.50 | 15.13 | 0.483 | 0.353 |
| Left Path Length | 8.35 | 4.41 | 7.38 | 3.69 | 0.618 | 0.659 |
| Right Path Length | 12.72 | 3.24 | 12.66 | 5.15 | 0.982 | 0.779 |
| Total Path Length | 21.06 | 7.20 | 20.04 | 7.85 | 0.789 | 0.904 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Players of Musical Instruments | | Not Players of Musical Instruments | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 10.17 | 4.49 | 12.02 | 5.09 | 0.451 | 0.547 |
| Time Cautery Used | 148.07 | 48.31 | 163.21 | 100.68 | 0.732 | 0.904 |
| Cautery Used in Air | 51.78 | 24.86 | 50.84 | 50.37 | 0.966 | 0.494 |
| Blood Loss | 462.00 | 295.59 | 376.23 | 159.99 | 0.406 | 0.494 |
| Adhesions Ripped | 3.20 | 1.79 | 10.34 | 22.59 | 0.498 | 1.000 |
| Adhesions Lysed | 99.67 | 0.82 | 98.14 | 6.40 | 0.574 | 0.968 |
| Left Path Length | 7.93 | 6.86 | 8.43 | 4.82 | 0.853 | 0.779 |
| Right Path Length | 11.70 | 3.84 | 13.20 | 5.11 | 0.530 | 0.602 |
| Total Path Length | 19.63 | 9.86 | 21.63 | 9.59 | 0.677 | 0.718 |

Analyzing the performance of **players and not players of team sports** and the salpingectomy's analysis parameters, came up with no significant differences between the performance of the two groups during both of the sessions, outputted by T-Test apart from Blood loss (in cc) during the pre-training assessment. However, Mann Whitney test for this particular parameter presented non-significant result.

**Table 3.3-35:** Pre- & Post-training results for analysis parameters of Salpingectomy and Players of Team Sports

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Players of Team Sports | | Not Players of Team Sports | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 12.18 | 4.71 | 13.67 | 5.29 | 0.515 | 0.552 |
| Time Cautery Used | 132.58 | 54.20 | 117.37 | 74.79 | 0.605 | 0.370 |
| Cautery Used in Air | 44.04 | 22.49 | 57.24 | 54.79 | 0.474 | 1.000 |
| Blood Loss | 663.47 | 338.28 | 401.35 | 193.71 | 0.045 | 0.131 |
| Adhesions Ripped | 11.27 | 12.69 | 5.25 | 5.12 | 0.224 | 0.238 |
| Adhesions Lysed | 100.00 | 0.00 | 93.00 | 18.77 | 0.229 | 0.095 |
| Left Path Length | 7.51 | 4.06 | 7.86 | 3.75 | 0.845 | 0.766 |
| Right Path Length | 12.74 | 3.89 | 12.61 | 5.55 | 0.954 | 0.766 |
| Total Path Length | 20.25 | 6.74 | 20.47 | 8.73 | 0.949 | 0.941 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Players of Team Sports | | Not Players of Team Sports | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 11.75 | 5.59 | 11.11 | 4.14 | 0.778 | 0.882 |
| Time Cautery Used | 173.17 | 88.18 | 140.95 | 87.68 | 0.426 | 0.412 |
| Cautery Used in Air | 44.90 | 29.52 | 58.72 | 57.47 | 0.496 | 0.941 |
| Blood Loss | 390.59 | 204.64 | 415.86 | 217.54 | 0.792 | 1.000 |
| Adhesions Ripped | 11.25 | 25.66 | 4.75 | 5.44 | 0.494 | 0.762 |
| Adhesions Lysed | 99.64 | 0.81 | 97.33 | 8.00 | 0.414 | 0.882 |
| Left Path Length | 8.04 | 5.43 | 8.58 | 5.50 | 0.829 | 0.941 |
| Right Path Length | 12.70 | 5.06 | 12.80 | 4.55 | 0.963 | 0.941 |
| Total Path Length | 20.74 | 10.11 | 21.38 | 9.17 | 0.885 | 0.882 |

**The senior residents used in both sessions, less left and total path length in comparison to the junior residents**. In fact, junior residents appear to have used more path-length on post than on pre-training. **T-test shows significance on left and total path length between the two groups while Mann-Whitney test does not show significance**. Therefore, we cannot conclude on the difference of the performance of the two groups on the post-training (**Table 3.3-35**).

**Table 3.3-36: Pre- & Post-training results for analysis parameters of Salpingectomy and Residency**

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Junior | | Senior | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 14.43 | 5.32 | 12.00 | 4.65 | 0.303 | 0.275 |
| Time for Cautery Used | 132.66 | 60.51 | 122.01 | 66.32 | 0.729 | 0.485 |
| Time for Cautery Used in Air | 44.36 | 21.04 | 53.00 | 47.38 | 0.655 | 0.699 |
| Blood Loss | 488.06 | 253.23 | 576.46 | 337.18 | 0.553 | 0.699 |
| Adhesions Ripped | 12.86 | 14.18 | 6.33 | 7.18 | 0.197 | 0.100 |
| Adhesions Lysed | 99.71 | 0.76 | 95.31 | 15.73 | 0.474 | 0.757 |
| Left Path Length | 9.27 | 4.94 | 6.81 | 2.95 | 0.261 | 0.351 |
| Right Path Length | 12.93 | 3.44 | 12.54 | 5.21 | 0.862 | 0.817 |
| Total Path Length | 22.20 | 7.48 | 19.35 | 7.59 | 0.432 | 0.311 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Junior | | Senior | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 14.19 | 5.00 | 10.00 | 4.30 | 0.065 | 0.067 |
| Time for Cautery Used | 186.69 | 93.54 | 143.58 | 83.39 | 0.304 | 0.351 |
| Time for Cautery Used in Air | 53.50 | 23.08 | 49.84 | 52.30 | 0.863 | 0.393 |
| Blood Loss | 362.67 | 228.47 | 423.12 | 198.06 | 0.544 | 0.588 |
| Adhesions Ripped | 18.08 | 32.67 | 3.50 | 3.53 | 0.325 | 0.385 |
| Adhesions Lysed | 100.00 | 0.00 | 97.85 | 6.61 | 0.406 | 0.438 |
| Left Path Length | 11.66 | 6.24 | 6.46 | 3.90 | 0.033 | 0.067 |
| Right Path Length | 15.24 | 5.13 | 11.41 | 4.06 | 0.083 | 0.097 |
| Total Path Length | 26.89 | 10.23 | 17.87 | 7.64 | 0.038 | 0.067 |

Finally, the performance of the participants did not present any statistically significance for any analysis parameters, between the group of participants that had **previous experience on the lapVR** and the group that does not have previous experience (**Table 3.3-36**).

## Table 3.3-37: Pre- & Post-training results of analysis parameters of Salpingectomy and Previous LapVR Experience

| Analysis Parameters | Pre-Training | | | | | |
|---|---|---|---|---|---|---|
| | Previous Experience | | No Previous Experience | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 12.00 | 6.48 | 13.06 | 4.67 | 0.709 | 0.494 |
| Time Cautery Used | 110.87 | 50.73 | 129.45 | 66.56 | 0.611 | 0.554 |
| Cautery Used in Air | 34.80 | 23.14 | 53.77 | 42.57 | 0.407 | 0.385 |
| Blood Loss | 727.17 | 317.38 | 500.11 | 296.36 | 0.192 | 0.178 |
| Adhesions Ripped | 7.00 | 10.13 | 9.20 | 10.82 | 0.719 | 0.411 |
| Adhesions Lysed | 100.00 | 0.00 | 96.06 | 14.17 | 0.593 | 0.494 |
| Left Path Length | 6.14 | 3.08 | 8.05 | 3.98 | 0.385 | 0.494 |
| Right Path Length | 13.86 | 5.58 | 12.38 | 4.45 | 0.578 | 0.494 |
| Total Path Length | 20.00 | 8.48 | 20.44 | 7.52 | 0.920 | 0.820 |

| Analysis Parameters | Post-Training | | | | | |
|---|---|---|---|---|---|---|
| | Previous Experience | | No Previous Experience | | T-Test p-values | Mann-Whitney Test p-values |
| | Mean | St. Dev. | Mean | St. Dev. | | |
| Time to Complete the Task | 11.75 | 6.24 | 11.39 | 4.72 | 0.900 | 0.963 |
| Time Cautery Used | 175.11 | 67.26 | 154.56 | 92.91 | 0.685 | 0.385 |
| Cautery Used in Air | 34.81 | 30.73 | 55.20 | 46.13 | 0.418 | 0.437 |
| Blood Loss | 530.44 | 260.33 | 369.84 | 185.24 | 0.167 | 0.211 |
| Adhesions Ripped | 4.00 | 4.00 | 9.23 | 21.08 | 0.681 | 1.000 |
| Adhesions Lysed | 99.00 | 1.15 | 98.50 | 6.00 | 0.873 | 0.249 |
| Left Path Length | 7.18 | 5.18 | 8.56 | 5.49 | 0.656 | 0.750 |
| Right Path Length | 11.58 | 3.97 | 13.04 | 4.95 | 0.593 | 0.617 |
| Total Path Length | 18.76 | 8.69 | 21.60 | 9.82 | 0.605 | 0.750 |

## 3.3.6. Assessment of the Lap-VR simulator-trained participants

### 3.3.6.1. Laparoscopic Clip a Vessel

On the following pages we present the results for the “Clip a Vessel” task, performed by the participants of the Group-A during their training in laparoscopy. Bringing on focus the **training realism**, 80% of the participants rated it as “Very realistic – Rather realistic”. All the participants (100%) found the appearance of the instruments as “Rather good – Very good” and 80% of the trainees think that the realism of instrument’s movement to be “Very good – Rather good”. In addition, 50% of the participants rated the interaction with objects as “Very good- Rather good” and 80% stated that the feedback was “Rather realistic – Very realistic” (**Table 3.3-37**). The responses of the participants showed that 40% claimed that the training capacity of the task was very good and 90% found the eye-hand coordination to be “Very good-Rather good”. Depth perception was rated as “Very good-Rather good” by 40% while instrument navigation was rated as “Very good-Rather good” by 90% and the cooperation between left and right hand was rated as “Very good” by 90%. On the other hand, the level of difficulty was rated as “Rather easy – Moderate” by 70% of the participants, although all of them think that the added value of these basic training skills was “Rather useful – Very useful” (**Table 3.3-38**). The following tables (**Tables 3.3-37 and 3.3-38**) present the mean and standard deviation of the scores for the LapVR simulator validation.

**Table 3.3-38: LapVR simulator validation: Descriptive statistics obtained from the feedback questionnaire for the “laparoscopic clip of a vessel” task**

| Questionnaire (Training Realism) | Mean | SD |
|---|---|---|
| Realism of the task | 4.2 | 1,033 |
| Realism of the instruments | 4.4 | 0.516 |
| Realism of Instrument Movement | 4.2 | 0.789 |
| Interaction of instruments with other objects | 3.6 | 0.966 |
| Adequacy of provided feedback | 4.1 | 0.738 |

**Table 3.3-39: LapVR simulator validation: Descriptive statistics obtained from the feedback questionnaire for the "laparoscopic clip of a vessel" task on the Lap-VRT simulator**

…continuation of Table 38

| Questionnaire (Training Realism) | Mean | SD |
|---|---|---|
| Training capacity of the task | 4.4 | 0.516 |
| Eye-hand coordination | 4.4 | 0.699 |
| Depth perception | 3.3 | 0.949 |
| Instruments navigation in general | 4.3 | 0.675 |
| Training left and right hand separately | 4.9 | 0.316 |
| Training cooperation between left and right hand | 4.7 | 0.483 |
| Level of difficulty | 3.3 | 0.823 |
| Added value for training basic skills | 4.5 | 0.527 |

The **Table 3.3-39** presents the actual results of the "Clip - a -Vessel" task in total and in a distinction between the first two and the last two repetitions of the task performed by the participants. The analysis renders evident that on the last two repetitions of the task, the performance of the trainees was improved when compared to the first two attempts, in all of the analysis parameters. Moreover, the performance in dropped clips with the left and right hand, in total right hand path and in the total time to complete the task was significantly different (better) than the first two attempts.

Table 3.3-40: Construct validity: for the "laparoscopic clip of a vessel" task on the Lap-VRT simulator

| Questionnaire (Training Realism) | Total | | First Two Attempts | | Last Two Attempts | | One Way ANOVA *(P-Values)* |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Clips applied in the marked area (number) | 4.08 | 1.25 | 4.60 | 2.68 | 4.10 | 0.45 | 0.416 |
| Dropped clips with left hand (number) | 0.38 | 0.71 | 0.70 | 1.13 | 0.05 | 0.22 | 0.016 |
| Dropped clips with right hand (number) | 0.39 | 0.78 | 1.00 | 1.34 | 0.10 | 0.31 | 0.006 |
| Total left hand total path (in meters) | 1.83 | 1.05 | 2.65 | 2.17 | 1.75 | 0.73 | 0.086 |
| Total right hand path length (in meters) | 1.74 | 0.68 | 2.25 | 0.83 | 1.54 | 0.56 | 0.003 |
| Total time to complete the task | 101.72 | 46.51 | 149.75 | 65.15 | 89.25 | 40.23 | 0.001 |

*One way ANOVAA and t-test results are identical

The next table (**Table 3.3-40**) is illustrative regarding the improvement of the participants' performance as the task is repeated. Evidently, **the trainees become better as much as repeat the task**. More precisely, **the results for dropped clips, the total path lengths and the time to complete the task are negatively and statistically significantly correlated with the number of repetitions**.

**Table 3.3-41:** Correlation between the analysis parameters of "Laparoscopic Clip a Vessel" task and Repetitions Attempted

| Analysis parameters of "clip – a – Vessel" task | | Repetitions attempted |
|---|---|---|
| **Number of Clips applied in marked areas (in number)** | Correlation Coefficient | -0.022 |
| | Sig. (2-tailed) | 0.770 |
| **Number of Dropped Clips with the Left hand (in number)** | Correlation Coefficient | -0.044 |
| | Sig. (2-tailed) | 0.549 |
| **Number of Dropped Clips with the Right hand (in number)** | Correlation Coefficient | -0.316** |
| | Sig. (2-tailed) | 0.000 |
| **Total Left hand path length (in meters)** | Correlation Coefficient | -0.319** |
| | Sig. (2-tailed) | 0.000 |
| **Total Right hand path length (in meters)** | Correlation Coefficient | -0.403** |
| | Sig. (2-tailed) | 0.000 |
| **Total Time to Complete the Task (in seconds)** | Correlation Coefficient | -0.520** |
| | Sig. (2-tailed) | 0.000 |

** Correlation is significant at the 0.05 level (2-tailed).*

*** Correlation is significant at the 0.01 level (2-tailed).*

The scatter plots on this page graphically illustrate the relationship between the analysis parameters of the task and the number of repetitions.

**Figure 3.3-49b:** **Scatter plot of Number of Clips applied in marked areas (in number) or Total time to Complete the Task (in seconds) versus Repetitions attempted (in number)**

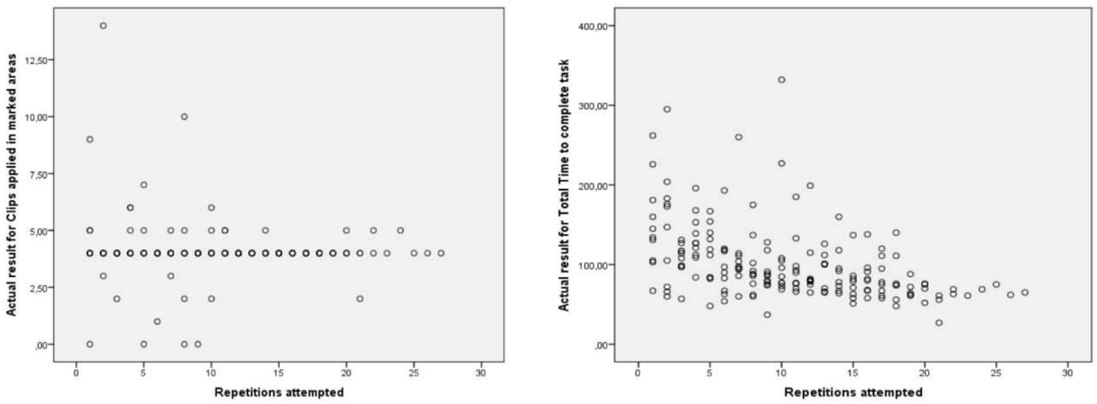


**Figure 3.3-50:** **Scatter plot for Number of Dropped Clips with Left (in number) or the Number of Dropped Clips with Right Hand (in number) versus Repetitions attempted (in number)**

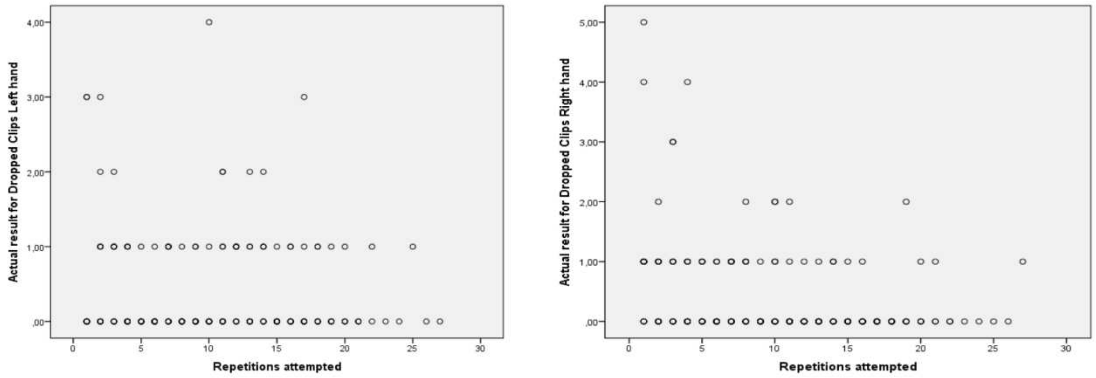
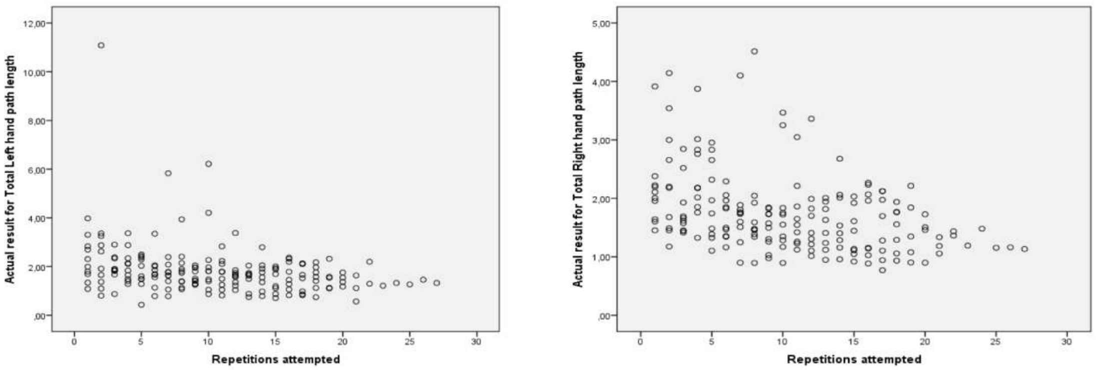


**Figure 3.3-51: Scatter plot of Path lengths (in meters) versus Repetitions attempted**



### 3.3.6.2. Laparoscopic Peg Transfer

On the following pages we present the results for the "Laparoscopic Peg Transfer" task, performed by the participants of the Group-A. Bringing in focus the training realism, 90% of the participants rated it as "Very realistic – Rather realistic". All the participants (100%) found the appearance of the instruments as "Rather good – Very good" and 90% of the trainees think of the realism of instrument's movement to be "Very good – Rather good". In addition, **70% of the participants rated the interaction with objects as "Very realistic- Rather realistic"** and **80% stated that the feedback was "Rather realistic – Very realistic"** (**Table 3.3-41**). The responses of the participants showed that **60% claimed that the training capacity of the task was very good** and **100% found the eye-hand coordination to be "Very good-Rather good". Depth perception was rated as "Very good-Rather good" by 50%** while instrument navigation was rated as "Very good-Rather good" by 90% and the cooperation between left and right hand was rated as "Very good" by 100%. On the other hand, the level of difficulty was rated as "Rather easy – Moderate" by 60% of the participants, although all of them think that the added value of these basic training skills was "Rather useful – Very useful" (**Table 3.3-42**). The following tables (**Tables 3.3-41 and 3.3-42**) present the mean and standard deviation of the scores for the face validity.

**Table 3.3-42: LapVR simulator validation: Descriptive statistics obtained from the feedback questionnaire for the "laparoscopic peg transfer" task on the Lap-VRT simulator**

| Questionnaire (Training Realism) | Mean | SD |
|---|---|---|
| Realism of the task | 4.4 | 0.699 |
| Realism of the instruments | 4.5 | 0.527 |
| Realism of Instrument Movement | 4.3 | 0.675 |
| Interaction of instruments with other objects | 3.8 | 0.919 |
| Adequacy of provided feedback | 4.0 | 0.943 |

**Table 3.3-43: LapVR simulator validation: Descriptive statistics obtained from the feedback questionnaire for the "laparoscopic peg transfer" task on the Lap-VRT simulator**

…continuation of Table 41

| Questionnaire (Training Realism) | Mean | SD |
|---|---|---|
| Training capacity of the task | 4.5 | 0.707 |
| Eye-hand coordination | 4.6 | 0.516 |
| Depth perception (Very Bad - Very Good) | 3.4 | 1.174 |
| Depth perception (Not realistic - Very realistic) | 3.2 | 1.229 |
| Instruments navigation in general | 4.4 | 0.699 |
| Training left and right hand seperately | 4.8 | 0.422 |
| Training cooperation between left and right hand | 4.8 | 0.422 |
| Level of difficulty | 3.4 | 0.843 |
| Added value for training basic skills | 4.5 | 0.527 |

The **Table 3.3-43** presents the actual results of the "Laparoscopic Peg Transfer" task in total and in a distinction between the first two and the last two repetitions of the task performed by the participants. The analysis renders evident that **on the last two repetitions of the task, the performance of the trainees was improved when compared to the first two attempts, in all of the analysis parameters**. In addition, this improvement is statistically significant for all of the analysis parameters except for the Number of Dropped Pegs with Right Hand.

**Table 3.3-44: Construct validity: for the "laparoscopic peg transfer" task on the LapVR simulator**

| Questionnaire (Training Realism) | Total | | First Two Attempts | | Last Two Attempts | | One Way ANOVA *(p-values)* |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Number of dropped pegs with left hand (in number) | 0.64 | 0.90 | 1.40 | 1.64 | 0.45 | 0.76 | 0.024 |
| Left hand total path lentgh (in meters) | 2.56 | 1.02 | 3.38 | 1.45 | 2.23 | 0.60 | 0.002 |
| Number of Dropped Pegs with Right Hand (in number) | 0.76 | 1.11 | 0.85 | 1.27 | 0.40 | 0.50 | 0.148 |
| Right hand total path length (in meters) | 2.59 | 1.05 | 3.09 | 1.28 | 2.18 | 0.54 | 0.006 |
| Total time to complete task (in seconds) | 124.09 | 56.02 | 184.70 | 80.07 | 104.45 | 30.71 | 0.000 |

*One way ANOVAA and t-test results are identical

The next table (**Table 3.3-44**) is illustrative regarding the improvement of the participants'' performance as the task is repeated. Evidently, **the trainees become better as much as repeat the task**. More precisely, **the results for dropped pegs, the path lengths and time to complete the task are negatively and statistically significantly correlated with the number of repetitions**.

**Table 3.3-45: Correlation between analysis parameters of "Laparoscopic Peg Transfer" task and Repetitions Attempted**

| **Analysis parameters of "Laparoscopic Peg Transfer" task** | | **Repetitions Attempted** |
|---|---|---|
| **Number of dropped pegs with Left Hand (in number)** | Correlation Coefficient | -0.222** |
| | Sig. (2-tailed) | 0.004 |
| **Left hand total path length (in meters)** | Correlation Coefficient | -0.323** |
| | Sig. (2-tailed) | 0.000 |
| **Number of dropped pegs with Right Hand (in number)** | Correlation Coefficient | -0.059 |
| | Sig. (2-tailed) | 0.445 |
| **Right hand total path length (in meters)** | Correlation Coefficient | -0.226** |
| | Sig. (2-tailed) | 0.003 |
| **Total Time to complete task (in seconds)** | Correlation Coefficient | -0.514** |
| | Sig. (2-tailed) | 0.000 |

** Correlation is significant at the 0.05 level (2-tailed).*

*** Correlation is significant at the 0.01 level (2-tailed).*

The scatter plots on this and the next page graphically illustrate the relationship between the analysis parameters of the task and the number of repetitions.

**Figure 3.3-52:** **Scatter plot for Number of Dropped Pegs with Left Hand (in number) or Number of Dropped Pegs with Right Hand (in number) versus Repetitions attempted (in number)**

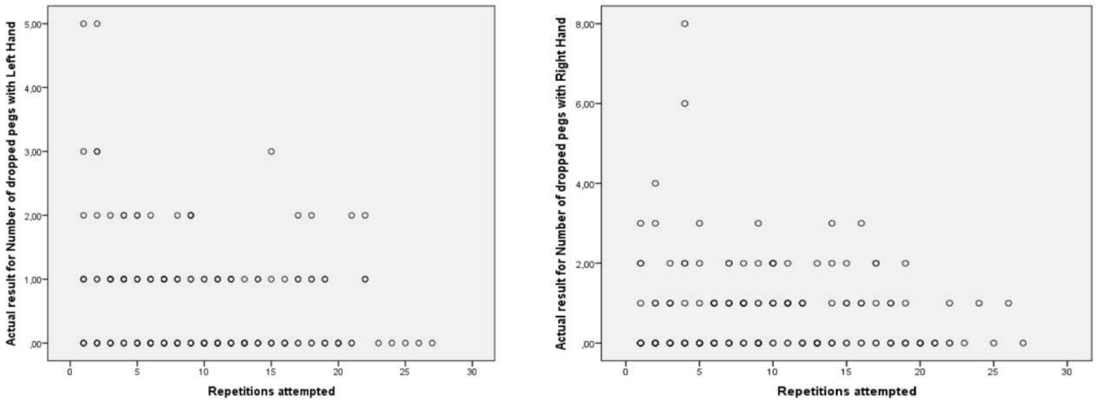


**Figure 3.3-53:** **Scatter plot for Path Lengths (in number) versus Repetitions attempted (in number)**

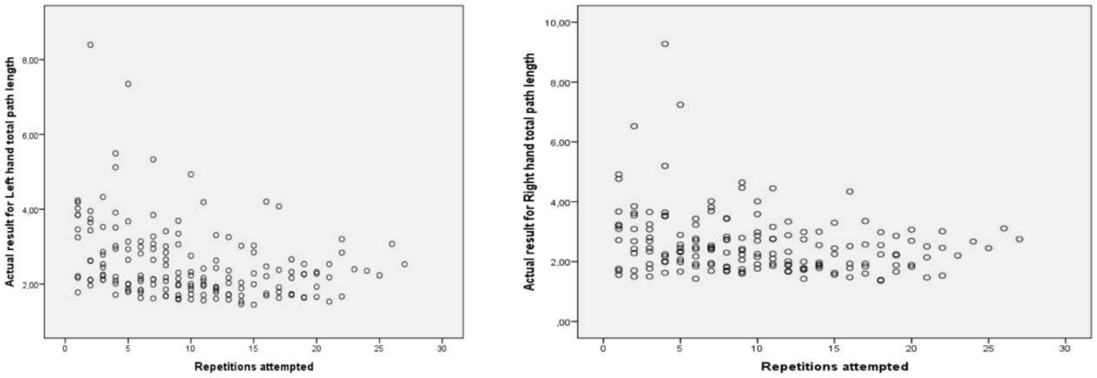
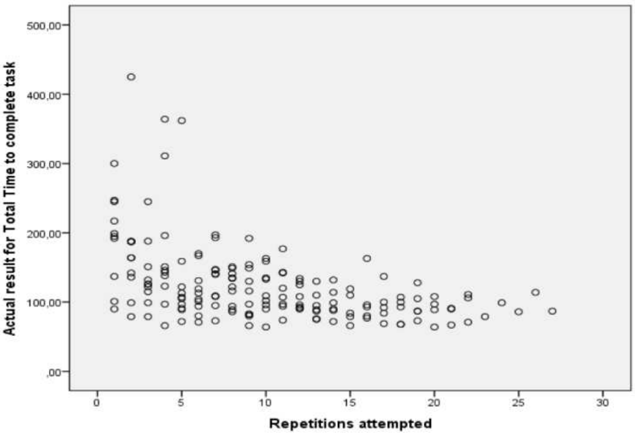


**Figure 3.3-54:** Scatter plot for Total Time to Complete the Task (in seconds) versus Repetitions attempted (in number)



### 3.3.6.3. Laparoscopic Cutting

On the following pages we present the results for the "Laparoscopic Cutting" task, performed by the participants of the Group-A during their training on the LapVR simulator. Bringing in focus the training realism, 90% of the participants rated it as "Very realistic – Rather realistic". 90% found the appearance of the instruments as "Rather good – Very good" and 80% of the trainees think that the realism of instrument's movement to be "Very good – Rather good". In addition, 80% of the participants rated the interaction with objects as "Very realistic- Rather realistic" and 80% stated that the feedback was "Rather realistic – Very realistic" (**Table 3.3-45**). The responses of the participants showed that 40% claimed that the training capacity of the task was very good and 80% found the eye-hand coordination to be "Very good-Rather good". Depth perception was rated as "Very good-Rather good" by 30% while instrument navigation was rated as "Very good-Rather good" by 80% and the cooperation between left and right hand was rated as "Very good" by 100%. On the other hand, the level of difficulty was rated as "Rather difficult – Difficult" by 70% of the participants, although all of them think that the added value of these basic training skills was "Rather useful – Very useful" (**Table 3.3-46**). The following tables (**Tables 3.3-45 and 3.3-46**) present the mean and standard deviation of the scores.

**Table 3.3-46: LapVR simulator validation: Descriptive statistics obtained from the feedback questionnaire for the "Laparoscopic Cutting" task on the LapVR simulator**

| **Questionnaire (Training Realism)** | **Mean** | **SD** |
|---|---|---|
| Realism of the task | 4.3 | 0.675 |
| Realism of the instruments | 4.4 | 0.699 |
| Realism of Instrument Movement | 4.1 | 0.738 |
| Interaction of instruments with other objects | 4.1 | 0.738 |
| Adequacy of provided feedback | 4.1 | 1.287 |

**Table 3.3-47: LapVR simulator validation: Descriptive statistics obtained from the feedback questionnaire for the "Laparoscopic Cutting" task on the Lap-VRT simulator**

…continuation of Table 45

| Questionnaire (Training Realism) | Mean | SD |
|---|---|---|
| Training capacity of the task | 4.3 | 0.675 |
| Eye-hand coordination | 4.3 | 0.823 |
| Depth perception | 2.8 | 1.135 |
| Instruments navigation in general | 4.1 | 0.738 |
| Training left and right hand separately | 4.7 | 0.483 |
| Training cooperation between left and right hand | 4.7 | 0.483 |
| Level of difficulty | 3.9 | 0.738 |
| Added value for training basic skills | 4.5 | 0.707 |

The **Table 3.3-47** presents the actual results of the "Laparoscopic Cutting" task **in total and in a distinction between the first two and the last two repetitions of the task performed by the participants**. The analysis renders evident that **on the last two repetitions of the task, the performance of the trainees was improved when compared to the first two attempts, in all of the analysis parameters except for the percentage cutting out of boundary area with left hand**. In addition, **this improvement is statistically significant for the left hand total path, the number of unsuccessful cutting attempts with right hand and the time to complete the task**.

**Table 3.3-48: Construct validity: for the "Laparoscopic Cutting" task on the LapVR simulator**

| Questionnaire (Training Realism) | Total | | First Two Attempts | | Last Two Attempts | | ANOVA *(P-Values)* |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Average grasping tension (in simulator force units) | 9.22 | 3.16 | 10.10 | 3.08 | 9.00 | 3.26 | 0.279 |
| Left Hand Total Path Length (in meters) | 3.21 | 1.88 | 3.82 | 1.69 | 2.71 | 1.68 | 0.044 |
| Number of Unsuccessful Cutting Attempts with Left Hand (in number) | 2.11 | 2.55 | 4.05 | 4.10 | 2.45 | 2.93 | 0.164 |
| Percentage Cutting out of Boundary Area with left hand (in %) | 1.01 | 3.85 | 0.50 | 0.83 | 0.80 | 3.58 | 0.717 |
| Percentage Cutting Out of Boundary Area with Right Hand (in %) | 0.32 | 1.17 | 0.90 | 1.94 | 0.15 | 0.67 | 0.111 |
| Right Hand Total Path Length (in meters) | 2.86 | 1.68 | 3.61 | 2.56 | 2.60 | 0.95 | 0;108 |
| Number of Unsuccessful Cutting Attempts with Right Hand (in number) | 3.96 | 4.56 | 5.90 | 6.67 | 1.80 | 2.71 | 0.015 |
| Total time to complete task (in seconds) | 208.63 | 118.01 | 294.45 | 147.62 | 166.60 | 67.21 | 0.001 |

*One way ANOVAA and t-test results are identical

The next table (**Table 3.3-48**) is illustrative regarding the improvement of the participants'' performance as the task is repeated. Evidently, **the trainees become better as much as repeat the task**. More precisely, **all results except the number of unsuccessful cutting attempts with left hand are negatively and statistically significantly correlated with the number of repetitions**.

## Table 3.3-49: Correlation between analysis parameters of "Laparoscopic Cutting" task and Repetitions Attempted

| Analysis parameters of "Laparoscopic Cutting" task | | Repetitions attempted |
|---|---|---|
| **Average Grasping Tension (in simulator force units)** | Correlation Coefficient | -0.240** |
| | Sig. (2-tailed) | 0.003 |
| **Left hand path length (in meters)** | Correlation Coefficient | -0.336** |
| | Sig. (2-tailed) | 0.000 |
| **Number of Unsuccessful Cutting Attempts with Left Hand (in number)** | Correlation Coefficient | -0.095 |
| | Sig. (2-tailed) | 0.244 |
| **Percentage Cutting Out of Boundary Area with Left Hand (in %)** | Correlation Coefficient | -0.190* |
| | Sig. (2-tailed) | 0.019 |
| **Percentage Cutting Out of Boundary Area with Right Hand (in %)** | Correlation Coefficient | -0.295** |
| | Sig. (2-tailed) | 0.000 |
| **Right Hand Path Length (in meters)** | Correlation Coefficient | -0.222** |
| | Sig. (2-tailed) | 0.006 |
| **Number of Unsuccessful Cutting Attempts with Right Hand (in number)** | Correlation Coefficient | -0.197* |
| | Sig. (2-tailed) | 0.015 |
| **Total Time to complete task (in seconds)** | Correlation Coefficient | -0.531** |
| | Sig. (2-tailed) | 0.000 |

** Correlation is significant at the 0.05 level (2-tailed).*

*** Correlation is significant at the 0.01 level (2-tailed).*

**Figure 3.3-55: Scatter plot for Average Grasping Tension (in simulator force units) or Time to Complete the Task (in seconds) versus Repetitions attempted (in number)**

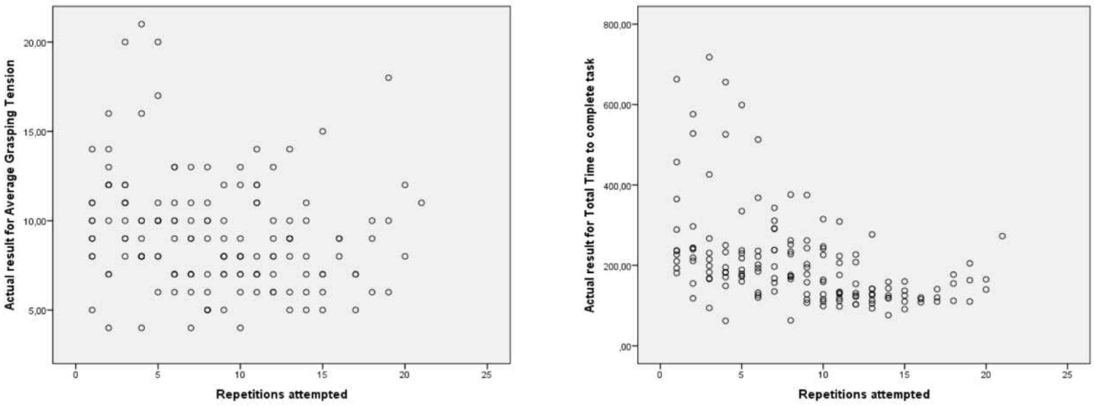


**Figure 3.3-56: Scatter plot for Path lengths (in meters) versus Repetitions attempted (in number)**

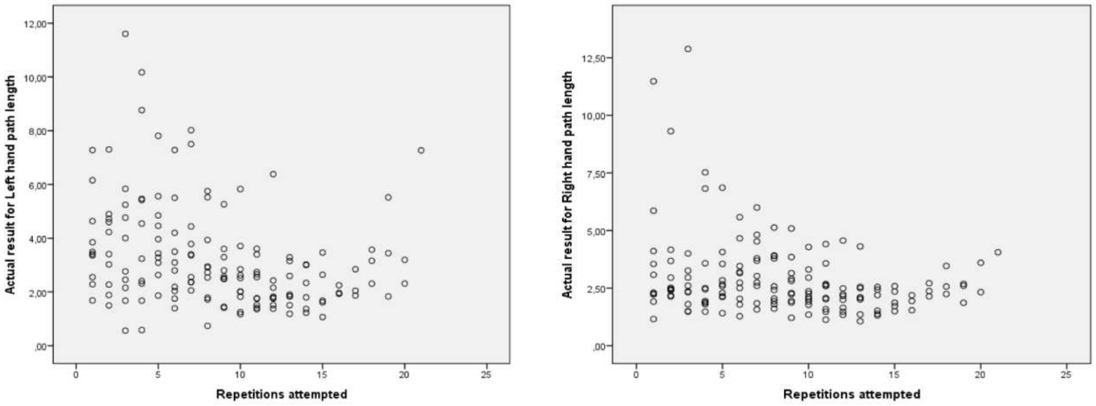


**Figure 3.3-57:** Scatter plot for Number of Unsuccessful Cutting Attempts (in number) versus Repetitions attempted

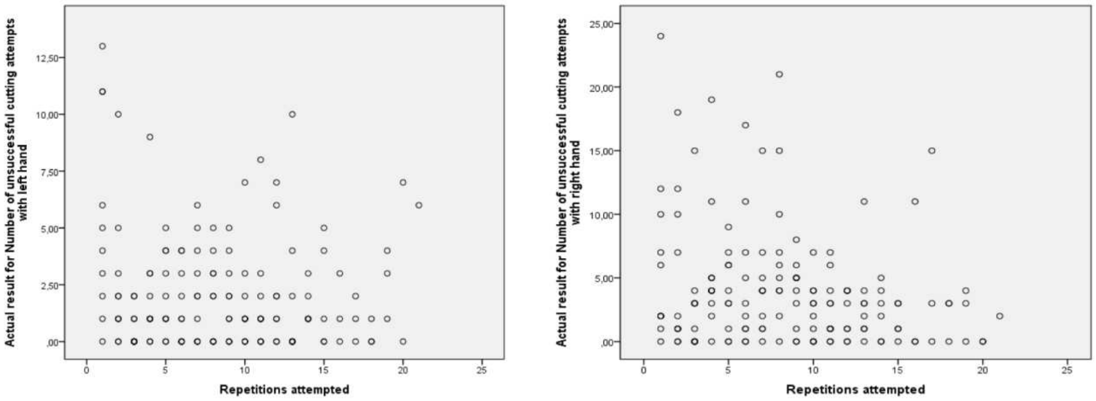
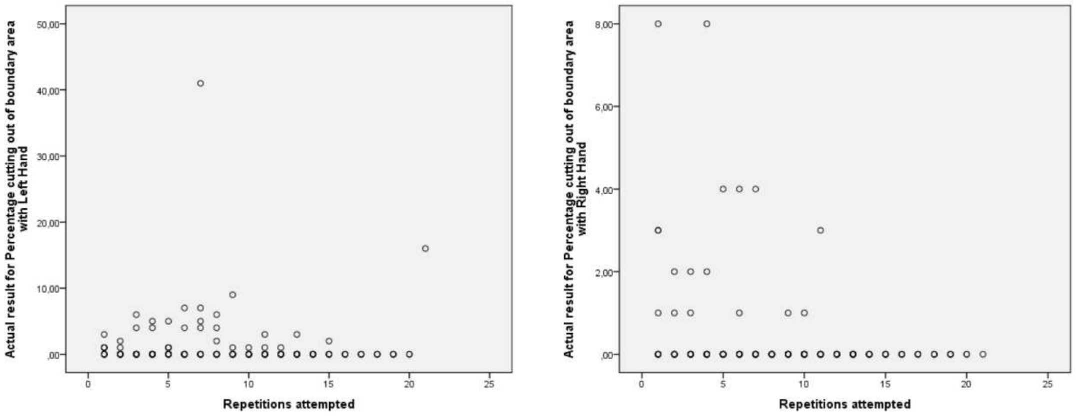


**Figure 3.3-58:** Scatter plot for Percentage Cutting Out of Boundary Area with Left or Right Hand (in %) versus Repetitions attempted (in number)



## 3.3.7. Assessment of the Box-trainer-trained participants

### 3.3.7.1. Laparoscopic Ovarian Cystectomy on Laparoscopic Box-Trainer Simulator

On the following pages we present the results for the "Laparoscopic Ovarian Cystectomy" task, performed by the participants of the Group-B during their laparoscopic training. The analysis shows that 90% of the participants responded "Yes for sure – Rather yes" regarding whether the training goal was reached. Furthermore, all participants claimed that the set-up and the training capacity of the task was "Rather-Very good". Finally, 90% of the participants think that the level of difficulty was "difficult or rather difficult" and the value added for training basic skills was "very or rather useful".

**Table 3.3-50: Descriptive statistics obtained from the feedback questionnaire for the "Laparoscopic Ovarian Cystectomy" task on the Trainer Box simulator**

| **Questionnaire (Training Realism)** | **Mean** | **SD** |
|---|---|---|
| The training goal is reached | 4.6 | 0.699 |
| The setup of the task | 4.5 | 0.527 |
| Training Capacity | 4.5 | 0.527 |
| Level of Difficulty | 4.5 | 0.707 |
| Added value for training basic skills | 4.6 | 0.699 |

Focusing on the actual results of the task, **79.2% of the repetitions performed by the participants on the task was successfully completed and within the maximum allowable time**. There is no statistically significant difference between the first two and the last two attempts, for any of the analysis parameters, except for tend for significance for the minimal damage in the cystic wall (p = 0.060) (**Table 3.3-50**).

**Table 3.3-51: Construct validity for the “Laparoscopic Ovarian Cystectomy” task on the Trainer-Box simulator, among all participants.**

| **Analysis Parameters** | **Total** | | **First Two Attempts** | | **Last Two Attempts** | | **ANOVA** *(P-Values)* | **Mann Whitney U Test (p-values)** |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | | |
| Total Time to Complete the Task Repetition (in minutes) | 7.44 | 2.11 | 8.00 | 1.83 | 7.20 | 2.25 | 0.229 | - |
| Success for the Maximum Allowable Time (<=10 min) (yes = 1 or no = 2) | 1.21 | 0.41 | 1.30 | 0.47 | 1.25 | 0.44 | - | 0.799 |
| Total Path Length for Both Hands (in centimeters) | 12,227.00 | 7,632.00 | 13,419.00 | 7,225.00 | 12,663.00 | 7,048.00 | 0.740 | - |
| Frequency for Balloon Puncture (yes = 1 or no = 2) | 1.090 | 0.290 | 1.050 | 0.224 | 1.150 | 0.366 | - | 0.602 |
| Minimal Damage in the "Cystic Wall" | 1.740 | 0.440 | 1.950 | 0.224 | 1.600 | 0.503 | - | 0.060 |
| Success for a 7-cm Longitudinal Incision on the Ovarian Cortex (yes = 1 or no = 2) | 1.330 | 0.473 | 1.300 | 0.470 | 1.450 | 0.510 | - | 0.429 |
| Maximum Deviation from the Labeled – Line (in mm) | 1.057 | 1.534 | 1.575 | 1.935 | 1.500 | 1.987 | - | 0.583 |

*_No data for the particular parameters_

| **Analysis Parameters** | **Yes** | | **No** | | **Number of Repetitions** |
|---|---|---|---|---|---|
| | *%* | ***Frequency*** | *%* | ***Frequency*** | |
| Completion of the task | 79.2 | 95 | 20.8 | 25 | 120 |
| Success for the maximum allowable time (<=10 min) (yes = 1 or no = 2) | 79.2 | 95 | 20.8 | 25 | 120 |
| Success for a 7-cm longitudinal incision on the ovarian cortex (yes = 1 or no = 2) | 66.7 | 80 | 33.3 | 40 | 120 |
| Frequency for balloon puncture (yes = 1 or no = 2) | 90.8 | 109 | 9.2 | 11 | 120 |
| Minimal Damage in the "Cystic Wall" (yes = 1 or no = 2) | 25.8 | 31 | 74.2 | 89 | 120 |

As shown above, 79.2% of the participant’s repetitions resulted in successful completion of the task and within the allowable time. Moreover, **in 66.7% of the repetitions there was success regarding the 7-cm longitudinal incision on the ovarian cortex** and in **90.8% of them there was balloon puncture**. Finally, **in 25.8% of the repetitions there was a minimal damage in the “cystic wall”** (**Table 3.3-50**). The next table (**Table 3.3-51**) is illustrative regarding the improvement of the participants’’ performance as the task is repeated. **There is statistically significant correlation between analysis parameters and number of repetitions concerning total time to complete the task, success within allowable time, total path length and minimal damage of the cystic wall**.

**Table 3.3-52: Correlation between analysis parameters of “Laparoscopic Ovarian Cystectomy” task and Repetitions Attempted, among all participants**

| Analysis parameters of “Laparoscopic Ovarian Cystectomy” task | | Number of Repetitions |
|---|---|---|
| **Total Time to Complete the Task (in minutes)** | Correlation Coefficient | -0.185* |
| | Sig. (2-tailed) | 0.043 |
| **Success for the Maximum Allowable Time (< 10 min) (yes = 1, no = 2)** | Correlation Coefficient | -0.184* |
| | Sig. (2-tailed) | 0,045 |
| **Total Path Length for Both Hands (in centimeters)** | Correlation Coefficient | -0.227* |
| | Sig. (2-tailed) | 0.013 |
| **Balloon Puncture (yes = 1, no = 2)** | Correlation Coefficient | 0.078 |
| | Sig. (2-tailed) | 0.399 |
| **Success for a 7-cm Longitudinal Incision on the "Ovarian Cortex" within the allowed time (yes = 1, no = 2)** | Correlation Coefficient | -0.053 |
| | Sig. (2-tailed) | 0.562 |
| **Minimal Damage in the "Cystic Wall" (yes = 1, no = 2)** | Correlation Coefficient | -0.397** |
| | Sig. (2-tailed) | 0.000 |
| **Maximum Deviation from the Labeled-Line (in mm)** | Correlation Coefficient | -0.149 |
| | Sig. (2-tailed) | 0.104 |

** Correlation is significant at the 0.05 level (2-tailed).*

*** Correlation is significant at the 0.01 level (2-tailed).*

### 3.3.7.2. Laparoscopic Salpingotomy on Laparoscopic Box-Trainer Simulator

On the following pages we present the results for the "Laparoscopic Salpingotomy" task, performed by the participants of the Group-B during their laparoscopic training. The analysis shows that 80% of the participants responded "Yes for sure – Rather yes" regarding whether the training goal was reached. Furthermore, all participants claimed that the set-up and the training capacity of the task was "Rather-Very good". Finally, 60% of the participants think that the level of difficulty was "Rather-Very difficult" while all participants (100%) rated the value added for training basic skills as "Rather-Very useful" (**Table 3.3-52**).

**Table 3.3-53: Descriptive statistics obtained from the feedback questionnaire for the "Laparoscopic Salpingotomy" task on the Trainer Box simulator**

| Questionnaire (Training Realism) | Mean | SD |
|---|---|---|
| The training goal is reached | 4.5 | 0.85 |
| The set-up of the task | 4.8 | 0.422 |
| Training Capacity | 4.6 | 0.516 |
| Level of Difficulty | 3.7 | 0.949 |
| Added value for training basic skills | 4.5 | 0.527 |

Focusing on the actual results of the task, 91.1% of the repetitions of the task that the participants performed was completed successfully and within the maximum allowable time. **There is statistically significant difference between the first two and the last two attempts, for all the analysis parameters, excluding the success of longitudinal incision** (**Table 3.3-53**). As shown above, 91.1% of the participant's repetitions resulted in successful completion of the task and within the allowable time. Moreover, in 65.8% of the repetitions there was success regarding the longitudinal-incision (**Table 3.3-53**).

**Table 3.3-54: Construct validity for the "Laparoscopic Salpingotomy" task on the Trainer-Box simulator, among all participants**

| **Questionnaire (Training Realism)** | **Total** | | **First Two Attempts** | | **Last Two Attempts** | | **ANOVA *(p-values)*** | **Mann Whitney U Test *(p-values)*** |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | | |
| Total time to complete the task repetition (in minutes) | 3.86 | 2.75 | 6.38 | 3.05 | 2.27 | 1.08 | 0.000 | - |
| Success for the maximum allowable time (<=10 min) (yes = 1, no = 2) | 1.09 | 0.29 | 1.26 | 0.45 | 1.00 | - | - | 0.172 |
| Total path length for both hands (in centimeters) | 6,583;80 | 4,638.50 | 10;982.58 | 5,661.07 | 4.305.26 | 2,112.99 | 0.000 | - |
| Success of longitudinal incision (yes = 1, no = 2) | 1.34 | 0.48 | 1.26 | 0.45 | 1.53 | 0.51 | - | 0.172 |

**No data for the particular parameters*

| **Analysis Parameters** | **Yes** | | **No** | | **Number of Repetitions** |
|---|---|---|---|---|---|
| | *%* | ***Frequency*** | *%* | ***Frequency*** | |
| Completion of the task | 91.1 | 72 | 8.9 | 7 | 79 |
| Success for the maximum allowable time (<=10 min) % | 91.1 | 72 | 8.9 | 7 | 79 |
| Success of longitudinal incision (%) | 65.8 | 52 | 34.2 | 27 | 79 |

The next table (**Table 3.3-54**) is illustrative regarding the improvement of the participants' performance as the task is repeated. **There is statistically significant negative correlation between the first three analysis parameters and number of repetitions. Success for a longitudinal incision correlates positively to the number of repetitions (p=0.031)**.

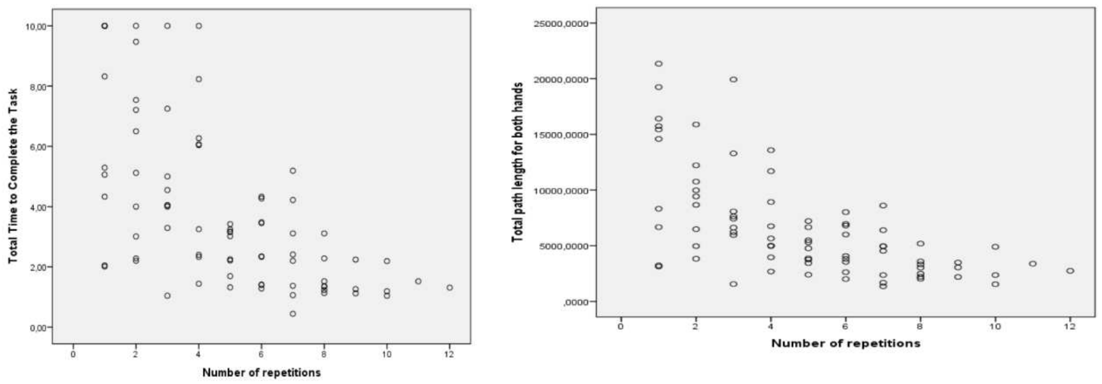
## **Table 3.3-55:** Correlation between analysis parameters of "Laparoscopic Salpingotomy" task and Repetitions Attempted

| **Analysis parameters of "Laparoscopic Ovarian Cystectomy" task** | | **Number of repetitions** |
|---|---|---|
| Total Time to Complete the Task (in minutes) | Correlation Coefficient | -0.659** |
| | Sig. (2-tailed) | 0.000 |
| Success for the Maximum Allowable Time (< 10 min) (yes = 1, no = 2) | Correlation Coefficient | -0.361** |
| | Sig. (2-tailed) | 0.001 |
| Total path length for both hands (in centimeters) | Correlation Coefficient | -0.654** |
| | Sig. (2-tailed) | 0.000 |
| Success for a longitudinal incision (yes = 1, no = 2) | Correlation Coefficient | 0.243* |
| | Sig. (2-tailed) | 0.031 |

* *Correlation is significant at the 0.05 level (2-tailed).*

** *Correlation is significant at the 0.01 level (2-tailed).*

## **Figure 59:** Scatter plot of Total Time to Complete the Task (in minutes) or the total path length for Both Hands (in centimeters) versus Repetitions Attempted



## 3.4. Discussion

The increasing use of minimally invasive surgery emphasizes the necessity to develop training programs for the improvement of laparoscopic skills. The clinical experience has shown that there is a significant learning curve for each surgeon and for each laparoscopic procedure, which includes 10 to 30 patients and during the learning time results in longer operating room time, higher complication rates, and higher conversion rates to open laparotomy, contributing to higher hospital costs [Watson et al, 1996, MacFadyen et al, 1998, Grantcharov et al, 2003]. Therefore, training outside the operating room using laparoscopic simulators would be more efficient than training on patients and provides a safe and controlled environment for learning basic laparoscopic skills without the risk to patients and without the operating room trainees' stress. The aim of this study was to determine the impact of training on a high-fidelity Lap-VR simulator compared to a low-fidelity laparoscopic Box-Trainer in developing laparoscopic skills, whereas the evaluation was conducted by the LapVR simulator, as there are controversies addressing the transferability of skills between different laparoscopic training modalities. It has been suggested that the VR simulators are able to assess the existing levels of laparoscopic skills of surgeons [Ahlberg et al, 2002, Schijven et al, 2005, Eriksen and Grantcharov 2005, Hassan et al, 2005]. Also, it seems that the VR simulators with the appropriate use are closer to real laparoscopic procedures now than previously thought [Hassan and Zielke, 2005]. In the present single-blinded prospective comparative trial 20 residents in Obstetrics and Gynaecology with minimal laparoscopic experiences were randomized into two groups for practical exercises on the LapVR simulator (group-A), or on the laparoscopic Box Trainer (group-B) and certain parameters were assessed. The candidates acted as their own control. Initial teaching session was given to obtain all the participants familiarization on the simulator and they were explained how to perform laparoscopic peg transfer, laparoscopic clipping and laparoscopic cutting using the Lap-VR simulator. They carried out the relatively simple gynaecological procedures of laparoscopic salpingotomy and laparoscopic salpingectomy for ectopic pregnancy before and after the training session on the Lap-VR simulator and certain parameters were assessed as well for comparing the training effect of the two different devices, by assessing the transferability of skills between them. Each subject completed a 5-point Likert-type questionnaire rating the training modalities about the face validity and their satisfaction at the end of the module. The 2 modalities for laparoscopic practice differ in some inherent characteristics, for example, the lack of depth perception or the poor realism of force feedback on the LapVR simulator (group-A) compared with the laparoscopic Trainer-Box simulator (group-B). In this study the tasks which were chosen for practice were not identical for both groups, as there is no consensus on which tasks to include in a basic laparoscopic training program in order to achieve the shortest learning curves. The practical exercises in the laparoscopic Trainer-Box were not the basic laparoscopic tasks, such as simple laparoscopic graspings or laparoscopic placing of objects but were more complicated exercises including the laparoscopic "ovarian cystectomy" for ovarian cyst task and the laparoscopic "salpingotomy" for ectopic pregnancy task. In addition to participant demographics and previous surgical laparoscopic experience, questions concerning the experience with the laparoscopic simulator as well as with the computer games were asked; no statistically significant differences were found between both groups in terms of these parameters.

Ten residents of the group-A were practiced on the LapVR simulator in two sessions lasting one and half hours each for two subsequent days in laparoscopic peg transfer, laparoscopic clipping and laparoscopic cutting using the LapVR simulator. As regards the task of the laparoscopic peg transfer on the LapVR simulator, most of the participants found it as very or rather good and realistic and had the some opinion for the realism of instrument's movements and the instruments navigation; they found it as rather easy or moderate. Also, over 70% of them thought that the interaction with objects and the feedback were very or rather realistic. All of them found the appearance of the instruments, the eye-hand coordination and the cooperation of both hands as very or rather good and 60% believed that the added value was very or rather useful. However the depth perception was rated as very or rather good by 50% of the subjects. The evaluation of the scores obtained from the LapVR simulator showed that on the last two repetitions of the task, the performances of the trainees were improved when compared to the first two attempts, in all of the analysis parameters. Also, the performances in dropped pegs, the left and right hand path lengths and the time to complete the task were significantly better in the first two attempts than the last two of them. Moreover, statistically significant negative correlation was found between the results for number of dropped pegs with the left hand, the path lengths with the left or the right hand and the total time to complete the task and the number of repetitions.

In terms of the laparoscopic cutting on the LapVR simulator, most of the participants found it as very or rather good and realistic and had the same opinion for the appearance of the instruments, the realism of instrument's movements, the instruments navigation, the interaction with objects and the eye-hand coordination. All of them found the cooperation of both hands as very or rather good and believed that the added value was very or rather useful. The level of difficulty was rated as rather difficult or difficult by 70% of them. However the depth perception was rated as very or rather good by 30% of the subjects. The evaluation of the scores obtained from the LapVR simulator showed that on the last two repetitions of the task, the performances of the trainees were improved when compared to the first two attempts, in all of the analysis parameters in all of the analysis parameters except for the percentage cutting out of boundary area with left hand. This improvement is statistically significant for the left hand total path length, the number of unsuccessful cutting attempts with right hand and the time to complete the task. These findings also are statistically significantly negative correlated with the number of repetitions.

In terms of the laparoscopic clip of a vessel on the LapVR simulator, most of the participants found it as very or rather good and realistic and had the some opinion for the appearance of the instruments, the eye-hand coordination, the instruments navigation and the cooperation of both hands; they rated the task as rather easy or moderate. Also, over 80% of them thought that the movements of the instrument and the feedback were very or rather realistic. All of them believed that the added value was very or rather useful. However the depth perception and the interaction with instruments were rated as very or rather good in less than the half of the subjects. The evaluation of the scores obtained from the LapVR simulator showed that on the last two repetitions of the task, the performances of the trainees were improved when compared to the first two attempts, in all of the analysis parameters. Also, the performances in the last two attempts in dropped clips with the left and right hand, in total right hand pathways and in the total time to complete the task were significantly better than the first two attempts. Moreover, statistically significant negative correlation was found between the results for dropped clips, the total path lengths and the time to complete the task and the number of repetitions.

The current study shows that the practice on the LapVR simulator improves certain laparoscopic skills like the laparoscopic peg transfer, the laparoscopic clipping and laparoscopic cutting skills assessed by the LapVR simulator. Loukas et al (2011a) showed that training on basic tasks (laparoscopic cutting, laparoscopic clipping, laparoscopic needle driving and laparoscopic knot tying) on the LapVR simulator had a significant impact in the improvement of complex tasks (laparoscopic adhesiolysis, laparoscopic bowel suturing and laparoscopic cholocystectomy) [Loukas et al, 2011a]. In addition, Loukas et al (2011b) investigated how the several performance parameters of the LapVR simulator contribute to the enhancement of key competencies in laparoscopic surgical skills and found that the experienced surgeons scored at a greater level of the residents in terms of time as well as dexterity [Loukas et al, 2011b]. Also, Iwata et al (2011) evaluated the construct validity of the LapVR simulator between expert surgeons and novice laparoscopic residents and found that the laparoscopic peg transfer and the laparoscopic cutting tasks were strong discriminators of laparoscopic experiences [Iwata et al, 2011]. Furthermore, Mansour et al (2012) assessed the technical and dexterity skills as in the laparoscopic peg transfer by measuring the total right- and left-hand length and in the laparoscopic clipping by measuring the vessel stretch and the number of misplaced clips and found improvement in some aspects of the laparoscopic surgical skills of the trainees [Mansour et al, 2012].

In the present study, ten participants of the group-B were practiced on the laparoscopic Box-Trainer in two sessions lasting one and half hours each for two subsequent days in the tasks of “laparoscopic ovarian cystectomy” for the management of ovarian cyst and “laparoscopic salpingotomy” for the management of ectopic pregnancy. In terms of the “laparoscopic ovarian cystectomy” on the laparoscopic Box-Trainer simulator, all of subjects claimed that the set-up and the training capacity were very or rather good. Most of the participants found the added value for training basic laparoscopic skills of the task as very or rather useful.  Also, most of them (90%) found the level of difficulty as difficult or rather difficult. There was no correlation for examined parameters between the first and last two repetitions of the task, although tend for significance was noted for the minimal damage in the cystic wall. Statistically negative significance was noted between the number of repetitions and (i) the total time to complete the task ($p = 0.043$), (ii) Success for the Maximum Allowable Time (< 10 min) ($p = 0.045$), (iii) the total Path Length for Both Hands ($p = 0.013$), (iv) Minimal Damage in the "Cystic Wall" ($p = 0.000$). These results demonstrate that the subjects obtained adequate effects of learning with this complex task (laparoscopic “ovarian cystectomy”).

In terms of the “laparoscopic salpingotomy” on the laparoscopic Box-Trainer simulator, all of subjects claimed that the set-up and the training capacity were very or rather good and found the added value for training basic laparoscopic skills as very or rather useful.  Also, most of them (60%) found the level of difficulty as difficult or rather difficult. The evaluation of the scores showed that there was a statistically significant correlation between the first and last two repetitions of the task and the total time to complete the task or the total path length for both hands  ($p = 0.000$) respectively. Also a statistically negative significance was noted between the number of repetitions and (i) the total time to complete the task ($p = 0.000$), (ii) the success for the maximum allowable time (within10 min) (iii) the total path length for both hands ($p = 0.000$). Success for a longitudinal incision correlates positively to the number of repetitions ($p=0.031$). The above findings are indications for improved learning laparoscopic abilities with this task. Though the primary goal of training is to increase performance levels, it is also important to decrease the variability in performance, which is demonstrated most clearly with the economy of instruments’ pathlength as it is shown in this task.

Our practical exercises in the laparoscopic Box-Trainer were designed to incorporate laparoscopic grasping and cutting application, which are all generic skills required to perform a laparoscopic management of an ectopic pregnancy. Hance et al (2005) assessed the changes of psychomotor skills of 3 separate laparoscopic cholecystectomy courses. Surgical experiences of the participants of each course varied from basic surgical trainees to surgical consultants. There were no significant differences in laparoscopic baseline experience between subjects attending the 3 courses as measured by the number of laparoscopic cholecystectomies performed. They found only significant improvement of laparoscopic skills after 2 of the 3 courses assessed in laparoscopic Box-Trainer by the laparoscopic clipping and laparoscopic cutting tasks [Hance et al, 2005]. One of the advantages of laparoscopic Box-trainer practicing in laparoscopic surgical tasks compared to training on real patients is the unlimited practice with trainer, while some disadvantage include the lack of a real clinical environment, the lack of patient communication and the lack of training on how to recognize and handle complications.

Evaluations for the laparoscopic salpingotomy task on the LapVR simulator revealed that the vast majority of participants were satisfied with this training method (70%). The participants' satisfaction according to the post - training questionnaire with the training modality as a whole according to the Simulator Type (Laparoscopic VR or laparoscopic Trainer-Box simulator) showed no differences between both groups. As shown in **Tables 3.3-4 and 3.3-5**, no statistically significant differences were found between the opinions of the participants of both groups (Laparoscopic Virtual Reality Simulator Group versus the Laparoscopic Box-Trainer Group) about the face validity of the laparoscopic salpingotomy procedure on the Lap-VRT simulator. Strong agreement among the subjects was evident from the low standard deviation. The lowest mean scores received for all of the questions were 2.36 for the depth perception and 3.60 for the realism of force feedback (haptics) addressing the problem of the Lap-VRT simulator in these aspects, which make the procedure less realistic. The highest mean score were 4.40 for the realism of camera simulation.

Gender was a factor, which was identified as influencing the pre-test performance of the laparoscopic salpingotomy on the VR simulator in terms of the total time to complete the task and the economy of both hands movements with favor to males. Thorson et al. [2011] enrolled 16 male and 16 female fourth-year students naive to VR laparoscopic simulator in their study to compare their performance in repetitive VRL tasks and found that female students performed worse than male students including economy of motion, time, and error [Thorson et al. 2011]. Same results found and other authors [Elneel et al, 2008, Madan et al 2008b, Rosental et al, 2006]. Our demographic data showed also the same difference in distribution of subjects playing team sports. It is important to note that during the post-test performance of the laparoscopic salpingotomy on the VR simulator no such statistically significances were found suggesting the improvement of the subjects after practicing. It seems that the gender or the habit of playing team sports did not affect the improvement of skills for the laparoscopic salpingotomy procedure. In the present study the only statistically significance was between the video players and the length of the incision for the laparoscopic salpingotomy during the post-training assessment (**Table 3.3-15**). It has been suggested that video game users acquire laparoscopic techniques quicker, and training on video games appears to improve performance [Lynch et al, 2010].

The comparison of the results of the pre-training tests showed no significant differences between the participants in group-A and group-B in their performance of the laparoscopic salpingotomy on the VR simulator (**Table 3.3-6**). **Table 3.3-7** gives the comparison of the results of the post-training tests between the group-A and the group-B. Laparoscopic salpingotomy was completed faster by the participants in the group-A than by participants in group-B. Participants in group-A used less path length than participants in group-B with both right and left hand. Also, a total blood loss showed a trend in favor of participants in group-A. However, there were no statistically significant differences between both groups with all the analysis parameters. Moreover, in comparison there was not a significant difference between pre- and post-training scores for all the analysis parameters (**Table 3.3-8**). In both groups, the median of the time to complete the task has reduced during the post-training as compared to the pre-training task. Group-A used higher movement economy in post-training as shown by the median in the boxplots, while for group B, the median was roughly the same for the pre- and post-training sessions. The **Table 3.3-9** summarizes the Spearman's correlation analysis of time to complete test and the parameters regarding the time of cautery used, the time of cautery used in air, the total blood loss, the incision length in the fallopian tube above the trophoblast and the total path length, at the pre- and post-training sessions. In pre-training session it correlates significantly with blood loss and the economy of movements. On the other hand, in the post-training session it significantly correlates with all the analysis parameters. Regarding group-A, in the post-training session, all the parameters correlated significantly to time for the completion of the task, contrary to pre-training performance where time correlated only with economy of movements. Focusing on Group B, in the post-training session, the time of cautery used, the time of cautery used in air, the incision length and the economy of movements correlated significantly with the completion time of the task contrary to pre-training performance where time correlated only with blood loss and economy of movements. Furthermore, the **Tables 3.3-10 and 3.3-11** summarize the Spearman's correlation analysis of the analysis parameters and the time for cautery used or the time of cautery used in air respectively at the pre- and post-training sessions. The correlation of time for cautery used becomes more concrete on the post-training performance for all participants as for the two groups separately. For the time of cautery used in air it is clear that for all participants there is a correlation of all the analysis parameters in the post-training session in contradiction to pre-training session, where no statistically significant correlation exists. Therefore, overall there were significant correlations between more analysis parameters of both groups during the post-training session, indicating that the VR simulator is a valid tool for developing laparoscopic skills as well as the laparoscopic Box-Trainer. To see the correlation between the task completion time and the economy of motions, a scatter plot is provided in **Figures 3.3-12 to 3.3-15**. A k-means analysis shows that the participants of the group-A seem to be more concentrated on the lower-left portion of the graph, as in pre-training or in post-training performance. On the other hand, participants of group-B appear to be more widely dispersed on the pre-training performance, although they in turn show a concentration to the lower-left side in the post-training session, meaning that they use less time and more economy in their movements to perform the task. Proficient laparoscopic surgeons have greater economy of hands and instrument movements and therefore path lengths as they make fewer movements in completing the required tasks [Hogle et al, 2007]. Arikatla et al, (2013) found statistically significant differences between the experts and the novices on the task time and the length of trajectory [Arikatla et al, 2013]. Also, many other researchers have used the length of trajectory as metric to differentiate laparoscopic skill levels [Iwata et al, 2011, Mansour et al, 2012, Pitzul et al, 2012, Larsen et al, 2006]. Loukas et al (2013) investigated the role of hand motion connectivity in the performance of a laparoscopic cholecystectomy on a VR simulator between experienced residents and beginners and found that experienced residents outperformed beginners in terms of the number, magnitude and covariation of the multivariate autoregressive weights [Loukas et al, 2013].

In the present study evaluations for the laparoscopic salpingectomy task on the Lap-VR simulator revealed that the vast majority of participants were satisfied with the choice of the task (85%). As shown in **Tables 3.3-21a and 3.3-21b**, no statistically significant differences were found between the opinions of the participants of both groups about the face validity of the laparoscopic salpingectomy procedure on the Lap-VR simulator. The lowest mean score received for all of the questions was 2.45 for the depth perception. Low was the score (3.80) for the realism of force feedback (haptics), while the highest mean scores were 4.40 for the software design. The question if the training capacity was reached with this task was rated to score 4–5 on the 5-point Likert scale by 80%. Participants rated depth perception as very or rather good by 45%, as moderate by 30% and as very or rather bad by 25%; no difference in opinion between participants practicing in group-A and group-B were noted.

In the task of laparoscopic salpingectomy on the Lap-VR simulator no connections were found between performance and gender or the habit of playing music instruments. In the pre-training performance a connection between players of team sport and blood loss was found in favor to no players (p= 0.045, t-test), but this was not found during the post-training assessment. In the post-training performance a connection was found between senior residents and left hand pathways (p = 0.033, t-test) or total pathways (p = 0.038, t-test) (**Table 3.3-35**). Moreover, in the post-training performance the right path length was related with use of video games (p= 0.033, t-test; (p= 0.039, Mann-Whitney U Test), (**Table 3.3-32**). Indeed, Grantcharov et al (2003) suggests that persons who regularly play computer games make fewer errors and have shorter learning curves than nonusers [Grantcharov et al, 2003], although there are contradictory reports. The comparison of the results of the pre-training tests showed no significant differences between the participants in group-A and group-B in their performance of the laparoscopic salpingectomy on the VR simulator except for the percentage of adhesions ripped by participants of Group-B that was significantly higher than Group-A (p=0.009) (**Table 3.3-23**). This difference was not found when the successful completion to the task was taken into account (**Table 3.3-24**). **Table 3.3-25** gives the comparison of the results of the post-training tests between the group-A and the group-B. Laparoscopic salpingectomy was completed faster by the participants in the group-A than by participants in group-B. Participants in group-B used less path length than participants in group-A with both right and left hand. However, there were no statistically significant differences between both groups with all the analysis parameters. Moreover, in comparison there was not a significant difference between pre- and post-training scores for all the analysis parameters (**Table 3.3-27**). The median of Group-B of the time to complete the task has reduced during the post-training for participants who completed the task as compared to pre-training; the opposite was observed regarding Group-A. The median for blood loss demonstrated a reduction on the post-training session, for both groups of participants. Between participants who successfully completed the operation, the total path length demonstrated a noticeable increase for Group-A during the post-training, when the exact opposite occurs for Group-B (**Table 3.3-28**). The **Table 3.3-29** summarizes the Spearman's correlation analysis of time to complete test and the parameters regarding the time of cautery used, the time of cautery used in air, the total blood loss, the path length for each hands and the total path lenght, at the pre and post training sessions. For all the participants, in pre- and post- training session it correlates significantly with the cautery used and the path lengths. In addition, for the subjects of the group-B a statistically significance correlation was found between the time to complete the task and the percentage of adhesions ripped. Linear Regression analysis between time of cautery used and total path length showed statistical significance with a very good fit, on the post-training session of both groups (**Figure 3.3-48**).

In the international literatures there are reports which validated the VR simulators. Grantcharov et al (2003) compared the learning curves for surgeons of three experience levels who performed 10 repetitions tasks on the Minimally Invasive

Surgical Trainer–Virtual Reality (MIST-VR) simulator and concluded that experienced surgeons do not benefit, while surgeons with moderate experience or beginners could probably gain significant improvement of their psychomotor skills by training in a virtual environment. It seems also that MIST-VR can precisely differentiate among groups of surgeons with different levels of experiences [Grantcharov et al, 2001, Grantcharov et al, 2003]. Ahlberg et al. reported that the virtual laparoscopy simulator (MIST-VR) did not improve the surgical skills of the students but the results with MIST-VR predicted surgical outcome during laparoscopic appendectomy in a porcine model (Ahlberg et al, 2002). Eriksen and Grantcharov [2005] randomized 24 surgeons to a practice-on-the LapSim VR group and were divided into two groups according to their experience in laparoscopic surgery (experienced versus beginners). They found that LapSim was able to differentiate between subjects with different laparoscopic experience indicating that this system can be used in training programs as a valid assessment tool [Eriksen and Grantcharov, 2005]. However, Steigerwald et al (2015) found that construct and predictive validity were strongly demonstrated for Fundamentals of Laparoscopic Surgery (FLS) tasks but only incompletely for Lap-VR [Streigerwald et al, 2015].

## 3.5. Conclusion

This randomized-prospective trial showed high levels of users' satisfaction with educational role of both Lap-VR and Box-Trainer simulators and neither Lap-VR simulator nor Box-Trainer showed any superiority over the other to training laparoscopic skills. We suggest that, laparoscopic training laboratories in laparoscopic training hospitals could include the VR simulators as a reasonable alternative to the Box-Trainer simulators for laparoscopic training of inexperienced in laparoscopy residents.

# 3.6. Abstract

**Background:** Laparoscopic surgery requires a very different set of psychomotor skills compared to open surgery, such as working in three-dimensional environment with two-dimensional view and four instead of six degrees of freedom, eye-hand coordination, depth perception and bimanual manipulation. Laparoscopic surgical training using laparoscopic box-trainers and laparoscopic virtual reality (VR) simulators overcomes these inherent differences and improves efficiency of learning and patient safety. The aim of this study was to compare the effectiveness of classic low-fidelity box-trainer and high-fidelity VR simulator and determine whether one has advantages over the other as training tool of inexperienced in laparoscopy residents in Obstetrics-Gynaecology for performing relatively simple laparoscopic procedures.

**Materials and Methods:** This is a prospective, randomized, blinded, comparative trial that enrolled 20 residents in Obstetrics and Gynaecology with minimal laparoscopic experiences to participate in practical exercises with either LapVR simulator (group-A), or laparoscopic Box-Trainer (group-B). The candidates acted as their own control.  Subjects within one group were not allowed to practice, on the opposing trainers. Initial teaching session was given to obtain all the participants familiarization on the VR simulator and they carried out laparoscopic salpingotomy and laparoscopic salpingectomy for ectopic pregnancy on the LapVR simulator (pretest). Performance was recorded by LapVR simulator for parameters such as total time taken, time of cautery used, total blood loss and economy of motion. The subjects were then randomized to either group-A or group-B for a series of laparoscopic exercises. The residents of group-A were practiced on LapVR simulator in laparoscopic peg transfer, clipping and cutting and certain parameters were assessed by LapVR simulator. The practical exercises on laparoscopic Trainer-Box were based in the tasks of laparoscopic "ovarian cystectomy" for ovarian cyst and laparoscopic "salpingotomy" for ectopic pregnancy and they were captured on DVD and scored for time and accuracy by a blinded expert investigator. After 2-day sessions lasting one and half hours each, all subjects were reassessed on the initial same procedures on LapVR simulator (post-test). Each subject completed a 5-point Likert-type questionnaire rating the training modalities about the face validity and their satisfaction at the end of the module. Improvements between the pre-test and post-test evaluations were compared between two groups using one way ANOVA analysis and Whitney U test.

**Results:** During training, subjects in group-A demonstrated statistically negative significance between the assessed parameters and the number of repetitions for the tasks of laparoscopic peg transfer, clipping and cutting. Also, the performances during these tasks in the last two attempts were significantly better than the first two, meaning that the practice on the LapVR simulator improves certain laparoscopic skills. In terms of the “laparoscopic ovarian cystectomy” on the laparoscopic Box-Trainer simulator the evaluation of the scores showed that there was a statistically significant correlation between the analysis parameters and number of repetitions concerning total time to complete the task, success within allowable time, total path length and minimal damage of the cystic wall. In terms of the “laparoscopic salpingotomy” for ectopic pregnancy on the laparoscopic Box-Trainer a statistically negative significance was noted between total time to complete the task or the total path length for both hands or the success within the maximum allowable time ($\leq$ 10 min) and the number of repetitions respectively. Success for a longitudinal incision correlated positively to the number of repetitions ($p=0.031$). These findings indicate improved laparoscopic learning skills. Performance of the 2 groups was comparable before and after training for both laparoscopic procedures. The participants’ satisfaction according to the post-training questionnaire was high for the training modality as a whole and showed no differences between groups.

**Conclusion:** The current study demonstrated high-levels of users’ satisfaction with the educational role of both LapVR and Box-Trainer simulators and neither LapVR simulator nor Box-Trainer showed any superiority over other for training laparoscopic skills to novice learners. We suggest that, laparoscopic training laboratories in laparoscopic training hospitals could include VR simulators as a reasonable alternative to Box-Trainer simulators for laparoscopic training of inexperienced residents in laparoscopy.

**Keywords:** Simulators, Box-trainer, Virtual Reality, LapVR, Gynaecologic, Laparoscopic Surgery, Training, Validation, Ectopic Pregnancy, Salpingotomy, Salpingectomy

# 3.7. Περίληψη

**Εισαγωγή**: Η λαπαροσκοπική χειρουργική απαιτεί ένα πολύ διαφορετικό σύνολο ψυχοσωματικών δεξιοτήτων συγκριτικά με την ανοιχτή χειρουργική, όπως είναι η διενέργεια χειρουργικών χειρισμών σε ένα τρισδιάστατο περιβάλλον με δυσδιάστατη απεικόνιση σε οθόνη, οι τέσσερις αντί για έξι βαθμοί ελευθερίας των χειρουργικών εργαλείων, ο συντονισμός ματιών-χεριών, η αντίληψη του βάθους και η ανάγκη δίχειρων χειρουργικών χειρισμών. Η λαπαροσκοπική χειρουργική με την χρήση των λαπαροσκοπικών εκπαιδευτικών-κουτιών και των λαπαροσκοπικών προσομοιωτών εικονικής πραγματικότητας υπερνικά αυτές τις εγγενείς διαφορές και βελτιώνει την αποτελεσματικότητα της μάθησης και της ασφάλειας των ασθενών. Ο σκοπός αυτής της μελέτης ήταν να συγκριθεί η αποτελεσματικότητα του κλασσικού χαμηλής-πιστότητας εκπαιδευτικού-κουτιού και του υψηλής-πιστότητας προσομοιωτή εικονικής πραγματικότητας και να καθορισθεί εάν το ένα εκπαιδευτικό μέσο υπερτερεί έναντι του άλλου ως εκπαιδευτικό εργαλείο σε λαπαροσκοπικά άπειρους ειδικευόμενους Μαιευτικής-Γυναικολογίας για την εξάσκησή τους στην εκτέλεση σχετικά απλών λαπαροσκοπικών χειρουργικών επεμβάσεων.

**Υλικά και Μέθοδοι:** Πρόκειται για μια προοπτική, τυχαιοποιημένη, τυφλή, συγκριτική μελέτη στην οποία συμμετείχαν 20 ειδικευόμενοι στη Μαιευτική-Γυναικολογία με ελάχιστη λαπαροσκοπική εμπειρία προκειμένου να λάβουν μέρος σε πρακτικές ασκήσεις είτε με λαπαροσκοπικό προσομοιωτή εικονικής πραγματικότητας (LapVR) (ομάδα A), είτε με λαπαροσκοπικό εκπαιδευτικό-κουτί (ομάδα- B). Ο κάθε εκπαιδευόμενος διενεργούσε ως δική του ομάδα ελέγχου. Στην αρχή δόθηκε μια συνεδρία καθοδήγησης και εξοικείωσης όλων των εκπαιδευομένων με τον προσομοιωτή εικονικής πραγματικότητας και στην συνέχεια όλοι οι εκπαιδευόμενοι διενήργησαν λαπαροσκοπική σαλπιγγοτομία και λαπαροσκοπική σαλπιγγεκτομία για έκτοπη κύηση στον LapVR (προ της πρακτικής άσκησης). Η απόδοση του κάθε εκπαιδευόμενου καταγράφηκε από τον προσομοιωτή LapVR για συγκεκριμένες παραμέτρους όπως είναι ο συνολικός χρόνος διενέργειας της επέμβασης, ο χρόνος που χρησιμοποιήθηκε η διαθερμία για καυτηριασμό, η συνολική απώλεια αίματος και

η οικονομία της κίνησης των χεριών. Οι ειδικευόμενοι στη συνέχεια τυχαιοποιήθηκαν είτε σε ομάδα-Α είτε σε ομάδα-Β για μια σειρά λαπαροσκοπικών ασκήσεων. Οι ειδικευόμενοι της ομάδας-Α ασκήθηκαν στον προσομοιωτή LapVR στην λαπαροσκοπική μεταφορά πασσάλων, στην λαπαροσκοπική τοποθέτηση μεταλλικών κλιπ και στο λαπαροσκοπικό κόψιμο και συγκεκριμένες παράμετροι αξιολογήθηκαν από τον προσομοιωτή LapVR. Οι πρακτικές ασκήσεις στο λαπαροσκοπικό εκπαιδευτικό-κουτί βασίστηκαν στο μοντέλο της λαπαροσκοπικής «ωοθηκικής κυστεκτομίας» και της λαπαροσκοπικής «σαλπιγγοτομίας» για έκτοπη κύηση και καταγράφηκαν σε DVD προκειμένου να βαθμολογηθούν τυφλά για τον συνολικό χρόνο και την ακρίβεια της κάθε άσκησης από έναν εμπειρογνώμονα. Μετά από 2-ημερών συνεδρίες διάρκειας μιάμιση ώρα η κάθε μία, όλοι οι ειδικευόμενοι επαναξιολογήθηκαν στις ίδιες αρχικές επεμβάσεις στον προσομοιωτή LapVR για τις ίδιες παραμέτρους (μετά την πρακτική άσκηση). Κάθε άτομο συμπλήρωσε ένα ερωτηματολόγιο 5-σημείων τύπου-Likert βαθμολογώντας τα εκπαιδευτικά μοντέλα ως προς την «κατά πρόσωπο εγκυρότητα» και την ικανοποίηση τους στο τέλος της ενότητας. Τα αποτελέσματα μεταξύ των αξιολογήσεων πριν και μετά την πρακτική άσκηση συγκρίθηκαν μεταξύ των δύο ομάδων, χρησιμοποιώντας την μονόδρομη ανάλυση ANOVA και την Whitney U δοκιμασία.

**Αποτελέσματα:** Κατά τη διάρκεια της εκπαίδευσης, τα άτομα της ομάδας Α κατέδειξαν στατιστικά αρνητική σημασία μεταξύ των παραμέτρων που αξιολογήθηκαν και τον αριθμό των επαναλήψεων για τις ασκήσεις της λαπαροσκοπικής μεταφοράς πασσάλων, την λαπαροσκοπική τοποθέτηση κλιπ και το λαπαροσκοπικό κόψιμο. Επίσης, οι επιδόσεις κατά τη διάρκεια αυτών των ασκήσεων στις δύο τελευταίες προσπάθειες ήταν σημαντικά καλύτερη από τις δύο πρώτες, που σημαίνει ότι η πρακτική στον προσομοιωτή LapVR βελτιώνει ορισμένες λαπαροσκοπικές δεξιότητες. Όσον αφορά την λαπαροσκοπική «κυστεκτομή της ωοθήκης» στο εκπαιδευτικό-κουτί η αξιολόγηση των βαθμολογιών έδειξε ότι υπήρχε στατιστικά σημαντική συσχέτιση μεταξύ των παραμέτρων που αναλύθηκαν και τον αριθμό των επαναλήψεων σχετικά με τον συνολικό χρόνο για να ολοκληρωθεί το έργο, την επιτυχία της άσκησης εντός του επιτρεπόμενου χρόνου, το συνολικό μήκος διαδρομής των δύο-χεριών και την ελάχιστη βλάβη στο «τοίχωμα της κύστεως». Όσον αφορά την «λαπαροσκοπική σαλπιγγοτομία" για έκτοπη κύηση στο λαπαροσκοπικό εκπαιδευτικό-κουτί παρατηρήθηκε στατιστικά αρνητική σημασία μεταξύ του συνολικού χρόνου ολοκλήρωσης της άσκησης ή το συνολικό μήκος διαδρομής και των δύο χεριών ή την ολοκλήρωση της άσκησης εντός του επιτρεπόμενου χρόνου ($\leq$ 10 λεπτά) και τον αριθμό των επαναλήψεων, αντίστοιχα. Η επίτευξη επιμήκους τομής επί της «σάλπιγγας» συσχετίσθηκε θετικά με τον αριθμό των επαναλήψεων (p=0.031). Τα ευρήματα αυτά υποδηλώνουν βελτίωση των λαπαροσκοπικών δεξιοτήτων εκμάθησης. Η απόδοση των 2 ομάδων ήταν συγκρίσιμη πριν και μετά την εκπαίδευση και για τα δύο εκπαιδευτικά μέσα. Η ικανοποίηση των συμμετεχόντων σύμφωνα με το ερωτηματολόγιο στο τέλος της ενότητας ήταν υψηλή για το εκπαιδευτικό πρόγραμμα στο σύνολό του και δεν υπήρχαν στατιστικά σημαντικές διαφορές μεταξύ των ομάδων.

**Συμπέρασμα:** Η παρούσα μελέτη κατέδειξε υψηλά επίπεδα ικανοποίησης των χρηστών σχετικά με την εκπαιδευτικό ρόλο των δύο λαπαροσκοπικών προσομοιωτών (LapVR και εκπαιδευτικό-κουτί) και ούτε ο προσομοιωτής εικονικής πραγματικότητας LapVR ούτε το λαπαροσκοπικό εκπαιδευτικό-κουτί παρουσίασε κάποια υπεροχή έναντι του άλλου για την εξάσκηση των ειδικευομένων χωρίς λαπαροσκοπική εμπειρία. Προτείνουμε, τα λαπαροσκοπικά εργαστήρια κατάρτισης σε εκπαιδευτικά νοσοκομεία λαπαροσκοπικής χειρουργικής να περιλαμβάνουν λαπαροσκοπικούς προσομοιωτές εικονικής πραγματικότητας ως μια λογική εναλλακτική λύση των λαπαροσκοπικών εκπαιδευτικών-κουτιών για την λαπαροσκοπική εκπαίδευση των άπειρων ειδικευόμενων Μαιευτικής-Γυναικολογίας.

**Λέξεις-κλειδιά:** Προσομοιωτής, εκπαιδευτικό-κουτί, εικονική πραγματικότητα, λαπαροσκοπικό εκπαιδευτικό κουτί, LapVR, γυναικολογικές επεμβάσεις, λαπαροσκοπική χειρουργική, κατάρτιση, έκτοπη κύηση, σαλπιγγοτομία, σαλπιγγεκτομία, ωοθηκική κυστεκτομία

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