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A Systematic Review and Meta-analyis on the Effect of Training with Nintendo® Wii™ in the Improvement of Basic Laparoscopic Skills Among Laparoscopic Novices

Marian R. Nuevo, MD and Maila Rose L. Torillo, MD, FPSGS, FPCS

Department of Surgery, Chinese General Hosptial

Videogames offer the usual skills needed for laparoscopy namely, eye-hand coordination, depth perception, and bimanual operation. The impact of playing videogames on basic laparoscopic skills is still ambiguous with some studies showing correlation and with other studies demonstrating little or no effect.

Objective: To determine the impact of training with Nintendo® Wii™ in the improvement of basic laparoscopic skill among laparoscopic novices by measuring the time to completion of eye-hand coordination task, two-hand manipulation task, grasping and cutting task or grasping and clipping tasks.

Methods: An electronic systematic search was done in online databases and search engines. This review included randomized prospective studies, written in English language, and published within the last 5 years. Participants included adults 19-29 years old, medical students and surgical residents, with a low video game experience, without or minimal experience in laparoscopic surgery and laparoscopic simulator. The studies compared the performance of participants in a laparoscopic simulator (Simbionix™ LapMentor™ or ProMIS) after training with Nintendo® Wii™ and measured their completion time of several tasks.

Results: Training with Nintendo® Wii™ showed improvement in time to completion of eye-hand coordination task, two-hand manipulation task, and grasping and clipping task. The study however showed equivocal results in the grasping and cutting tasks.

Conclusion: Training with Nintendo® Wii™ can be used as a training tool for the improvement of basic laparoscopic skills of laparoscopic novices.

Key words: Nintendo® Wii™, surgical skills, laparoscopic skills

Minimally invasive surgery has become part and parcel of the treatment options offered to patients. Laparoscopy, hence, has become a standard or an alternative modality in bringing cure to several diseases. Surgeons and surgical trainees alike are required to learn and refine their cognitive and psychomotor skills as they employ laparoscopy in their daily occupation.

It is well known that laparoscopic surgery entails skills that are far different from the usual open surgeries that surgeons perform. With laparoscopy, the surgeons are required to adapt in a surgical field with limited tactile feedback, necessitating the possession of eye-hand coordination, the ability to infer three-dimensional structures from two dimensional interface, and mastery of bimanual dexterity.[1] These skills can only be obtained through time and practice, hence, training for this must start during surgical residency to shorten the learning curve for minimally invasive surgery.

Virtual reality simulators and box trainers are methods that have been widely employed in residency programs to provide a training modality for surgical residents. Virtual reality simulators have the benefit of being able to objectively assess the user's performance and to teach properties such as anatomy, procedural skills and knowledge, without being dependent on human monitoring during training. However, the disadvantages of virtual simulators are its lack of natural sensory or haptic feedback, and mostly its cost. Hence, not all training hospitals have the means of procuring this modality. On the other hand, box trainers have the advantage of being

less expensive, accessible, easy to use, and being able to allow the trainee to familiarize themselves with laparoscopic instruments. Furthermore, the natural sensory or haptic feedback on the surgeon's hands is preserved. However, the disadvantages of using box trainers are its being less objective in assessing one's performance and the need of supervision during its training.[2]

Currently, other methods such as training with videogames have been explored and studied for its effect on laparoscopic skills as a means or an adjunct in training for laparoscopy. Videogames are cost-effective, and in a way, a method of training that is more entertaining compared to other methods. Videogames also offer the usual skills needed for laparoscopy namely, eye-hand coordination, depth perception, and bimanual operation. From previous studies, it has been shown and accepted that videogames improve eye-hand coordination, spatial visualization and rapid mental processing which are skills needed for minimally invasive surgery. Previous studies have also investigated the link between prior gaming habits and surgical skills only. However, these studies are only relevant in the process of selection and not in the training process of surgical residents. Nevertheless, the impact of playing videogames on basic laparoscopic skills is still ambiguous with some studies showing correlation with others demonstrating little or no effect.[1] Its usage as method of training for laparoscopy hasn't also been employed.

With minimally invasive surgery becoming more attractive during this time, it is important that training hospitals and centers become active in participating in the training of laparoscopic novices. Though the effect of videogames on laparoscopic skills has yet to be known, it can be incorporated or used as a training tool surgical trainees and consultants. With this method of training, it can both encourage and attract laparoscopic novices to hone their skills in laparoscopy and to overcome the learning curve that is currently evident among laparoscopic novices. This paper, therefore, aimed to determine the the impact of training with Nintendo® Wii™ in the improvement of basic laparoscopic skill among laparoscopic novices.

This review aimed to determine the impact of training with Nintendo® Wii™ in the improvement of basic laparoscopic skill among laparoscopic novices. In order to obtain this objective, the study likewise must obtain the to complete of eye-hand coordination task, two-hand manipulation task and other laparoscopic skills such as grasping and cutting, or grasping and clipping.

Methods

Criteria for Considering Studies for this Review

Type of Studies

This review only included randomized prospective studies, written in English language, and published within the last five years, with the full text of the study provided.

Types of Participants

The participants in the studies included are adults aged 19-29 years old, both male or female medical students and surgical residents, with the majority being right-handed. The participants included have a rare or low video-game experience (less than one hour/week in the last 10 years), with none or low (zero to four previous laparoscopic procedures) experience in laparoscopic surgery, and without or minimal experience with a laparoscopic simulator.

Types of Intervention

All included studies compared the performance of the participants in a laparoscopic simulator (Simbionix™ LapMentor™ or ProMIS) after training with Nintendo® Wii™ for at least one hour every day, for one to four weeks.

Types of Outcome Measures

- Completion Time (in seconds) of Eye-Hand Coordination Task
- Completion Time (in seconds) of Two-Hand Manipulation Task
- Completion Time (in seconds) of Grasping and Cutting or Grasping and Clipping Tasks

Excluded Studies

This review did not include studies with the following characteristics: studies that were comprised of participants with regular experience in laparoscopic surgeries and laparoscopic simulators studies whose participants had frequent video game experience, studies that were not randomized prospective papers, and studies that measured the outcomes through box trainers, and the use of other video games other than Nintendo® Wii™ as a training tool.

Search Methods for Identification of Studies

Electronic Searches

An electronic search was done in PUBMED, CENTRAL, Science Direct, Google and Yahoo search engines using the following key words: *Training with Videogames, Training with Nintendo® Wii™, Surgical Skills, Laparoscopic Skills, Effect on Surgical Skills, Effect on Laparoscopic Skills, Improvement on Surgical Skills, Improvement on Laparoscopic Skills*. The demonstration of the search strategy done in this review can be seen in Figure 1. Keywords were entered in online databases and search engines accordingly as ordered. After identifying and narrowing the searched items, the studies were then analyzed. Involved in this review were studies who met the inclusion criteria enumerated earlier and those who provided full text copies of their study.

1. Training with Video Games
2. Training with Nintendo® Wii™
3. Surgical Skills
4. Laparoscopic Skills
5. Effect on 3 *or* 4
6. Improvement on 3 *or* 4
7. 1 *or* 2
8. 7 and 3 *or* 4
9. 8 and 5 *or* 6

Figure 1. Search strategy

Data Collection and Analysis

The studies obtained from the systematic search were then critically appraised for their validity using the guide questions provided by the Journal of the American Medical Association (JAMA) in its published article last May 25, 1994 entitled *Users' Guide to the Medical Literature: IV. How to Use an Article about Therapy or Prevention*. Table 1 specifically shows the questions used in determining the validity of each study obtained in the review. Studies found to be valid were then included.

Table 1. Critical appraisal on articles about therapy or prevention.

1. Is the objective of the article comparing therapeutic interventions similar to your clinical dilemma?
2. Was the assignment of patients to treatment randomized?
3. Were all patients who entered the trial properly accounted and attributed at its conclusion?
   - Was follow up complete?
   - Were patients analyzed in the groups to which they were randomized?
4. Were patients, their clinicians and study personnel "blinded" to treatment?
5. Were the groups similar at the start of the trail?
6. Aside from the experimental intervention, were the groups treated equally?

Using the Cochrane Collaboration's Tool for assessing risk of biases as provided by the Cochrane Handbook for Systematic Reviews of Intervention, the assessment of risk of biases for the included studies was done. This review also utilized the Cochrane Data Extraction Template to gather and extract data from the studies involved.

Data from the studies included were combined and analyzed using Review Manager Software. Continuous variables were then calculated as the mean or median time to completion of the laparoscopic tasks performed in the studies. Statistical Heterogeneity was then assessed using the following: visual inspection of the graphic representation of the studies, chi^2 test with a P-value of less than 0.05 to indicate significant heterogeneity and I^2 for quantifying inconsistencies.

Results

Description of Studies

The electronic search done in PUBMED, CENTRAL and Science Direct yielded a total of 36 studies, while Google and Yahoo yielded a total of 29 studies. Only 12 studies were identified as potentially eligible after duplicates were removed. From these 12 studies, one study was excluded due to inability to access the full text of the paper and 11 studies remained for further assessment for eligibility. With the inclusion criteria mentioned in this paper, eight studies were excluded, and only three studies were included in this review. Figure 2 shows the summary of the results of the search done, while Table 2 shows the summary of the characteristics of the included studies in this review.

Excluded were studies whose objectives differ from this review, those that used other video games or methods as a training tool, and systematic reviews.

The three included studies had comparable participants, with only Nintendo® Wii™ used as a training tool for the participants involved. The three studies likewise had comparable methodology, determined similar outcomes and with objectives similar to this review.

Table 2. Characteristics of the included studies

Authors & Year	Method, Participants & Intervention	Outcomes Measured
Boyle E, et al. 2011 "Training surgical skills using nonsurgical tasks - can Nintendo® Wii™ Improve Surgical Performance?"	• Prospective Randomized Study • 22 Medical Students with no laparoscopic surgical experience, did not played videogames regularly, never played a Nintendo® Wii™ for more than 1 hour • 3 hours of structured practice on Nintendo® Wii™ (4 games: "Whack a Mole", "Asteroid Crash", "Alien Attacks" and "Dangerous Route") everyday for 5-7 days	• Bead Transfer Task • Glove Cutting Task • ProMIS Virtual Task
Giannotti D, et al. 2013 "Play to become a surgeon: impact of Nintendo® Wii™ training on laparoscopic skills"	• Prospective Randomized Study • 42 Surgical Residents (1st & 2nd Year) with lack of prior simulator experience, none or low experience in laparoscopic surgery (less than 5 laparoscopic procedures), low video-game experience (less than 1 hour a week in the last 10 years) • Systematic Nintendo® Wii™ training (3 games: "Sports Tennis", "Table Tennis" and "Battle at High Altitude") for 1 hour a day, 5 days a week, for 4 weeks	• Camera Manipulation • Eye Hand Coordination • Two Hand Manipulation Task • Completion of Virtual Laparoscopic Cholecystectomy
Middleton K, et al. 2013 "Improved nondominant hand performance on a laparoscopic virtual reality simulator after playing the Nintendo® Wii™"	• Single Blinded, Prospective Randomized Study • 23 Medical Students with no video game experience of more than 15 hours during the 4 weeks before the study, and with no experience on a virtual reality surgical simulator • 2 groups played Nintendo® Wii™ (3 games: "Shooting Range", "Pose Mii" and "Table Tennis") with Group A (2 hours)- 1 hour a day for 2 consecutive days, or 2 hours in one session and Group B (4 hours) - 1 hour a day for 4 consecutive days, 2 hours a day for 2 consecutive days, or 4 hours over the span of 3 days	• Eye Hand Coordination Task • Bimanual Clipping and Grasping Task • Two-Handed Manipulation Task

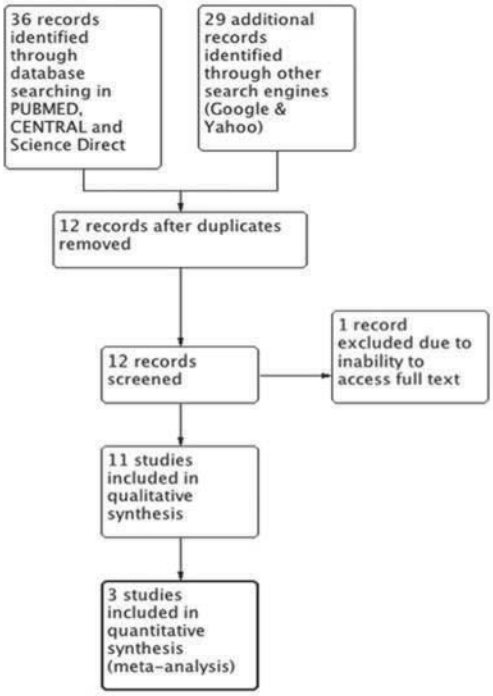

Figure 2. Study flow diagram

Risk of Bias in Included Studies

The summaries of risk of biases for the three included studies are shown in Figure 3 and Table 3. All the three studies have low risk for selection bias. The studies involved have exclusion criteria that were met before participants were enrolled in their studies. Furthermore, randomization was done in all three papers in the allocation of participants in the control or experimental group. The presence of performance bias in all three studies was not considered since blinding or participants could not be done due to the intervention involved, which is training with Nintendo® Wii™. There were no blinding personnel involved since the performance of the participants in all three studies was evaluated with a laparoscopic simulator. Hence, all three studies have low risk for attrition and reporting bias.

Effects of Interventions

The studies in this review determined the effect of training with Nintendo® Wii™ on Eye-Hand Coordination Tasks. Eye hand coordination task using the ProMis Surgical Simulator involved a Bead Transfer Task, with trainees using a laparoscopic instrument in their left and right hands to transfer beads to different numbered pots and to a small bag.[6] On the other hand, studies of Giannotti 2013[7] and Middleton 2013[1] involved a eye hand coordination task using the Simbionix™ LapMentor™ with participants utilizing laparoscopic instruments in each hand, one having a blue colored tip and the other a red colored tip. The participants were required to locate 10 flashing blue and red balls and touch them with the tool of the same color. All of these studies measured the time to completion in the involved task. After comparing participants' time to completion from their baseline scores, it was observed that training with Nintendo® Wii™ improved their time in the completion of the task performed. (Figure 4)

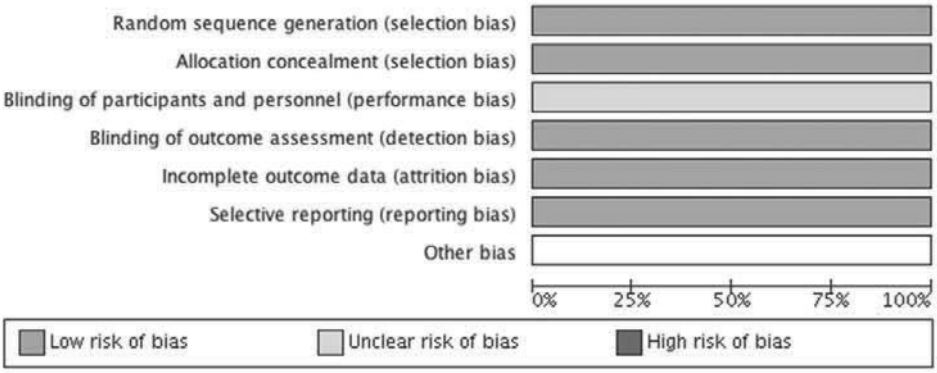

Figure 3. Risk of bias summary

Table 3. Risk of bias table

Boyle 2011

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Excluded participants with laparoscopic surgical experience, played video games regulary and previously played Nintento Wii for more than 1 hour.
Allocation concealment (selection bias)	Low risk	A simple block randomization scheme was used with block of 4 to keep numbers in each group similar.
Blinding of participants and personnel (performance bias)	Unclear risk	Not Applicable
Blinding of outcome assessment (detection bias)	Low risk	Assessement done using Lap Simulator
Incomplete outcome data (attrition bias)	Low risk	Form the 22 participants included 3 subjects dropped out
Selective reporting (reporting bias)	Low risk	Assessement done using Lap Simulator
Other bias	Unclear risk	

Giannotti 2013

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Completed an entrance questionnaire. Included participants without lack of prior laparoscopic simulator experience, none or low experience in laparoscopic surgery (less than 5), low video-game experience (less than 1 hour a week in the last 10 years).
Allocation concealment (selection bias)	Low risk	Participants were randomized according to a computer generatled list.
Blinding of participants and personnel (performance bias)	Unclear risk	Not Applicable
Blinding of outcome assessment (detection bias)	Low risk	Assessement done using Lap Simulator
Incomplete outcome data (attrition bias)	Low risk	No dropped outs
Selective reporting (reporting bias)	Low risk	Assessement done using Lap Simulator
Other bias	Unclear risk	

Middleton 2013

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Completed an entrance questionnaire. Excluded participants with video game experience of more than 15 hours during the 4 weeks beofre the study and experience in surigcal simulator.
Allocation concealment (selection bias)	Low risk	Participants were randomized using a random-number generator.
Blinding of participants and personnel (performance bias)	Unclear risk	Not Applicable
Blinding of outcome assessment (detection bias)	Unclear risk	Assessment done using Lap Simulator
Incomplete outcome data (attrition bias)	Low risk	No drop ~outs
Selective reporting (reporting bias)	Low risk	Assessement done using Lap Simulator
Other bias	Unclear risk	

The studies in this review also determined the effect of training with Nintendo® Wii™ in Two-Hand Manipulation Task. In both Giannotti 2013[6] and Middleton 2013[1], this task required participants to expose with two grasping tools by using traction, pulling and pushing the 9 balls hidden under a jelly mass. Adequately exposed balls turned from red to green indicating their readiness for retrieval and placement in an endobag. Again both studies performed this task using the Simbionix™ LapMentor™. Time to completion were noted and compared with their baseline scores. As seen in Figure 5, it can be observed that training with Nintendo® Wii™ improved the participants in the Two-Hand Manipulation Task.

The studies of Boyle 2011[6] and Middleton 2013[1] were also able to determine to effect of training with Nintendo® Wii™ on tasks involving grasping and cutting, or grasping and clipping. The task required the participant to cut a standard triangular shape from a stretched latex glove using a laparoscopic cutter and grasper.[6] The trainee is required to cut the shape accurately and to avoid making perforation in the bottom layer of the latex glove. In Middleton 2013, the trainees utilized grasping and clipping instruments. The task required clipping nine leaky ducts after pulling the device with a grasper while preventing the small poll from overflowing. As shown in Figure 6, the results were contrasting. Only training with Nintendo® Wii™ showed improvement in the grasping and clipping task, while equivocal results were seen in the grasping and cutting tasks.

Discussion

This review showed that training with Nintendo® Wii™ improved both eye-hand coordination and two-hand

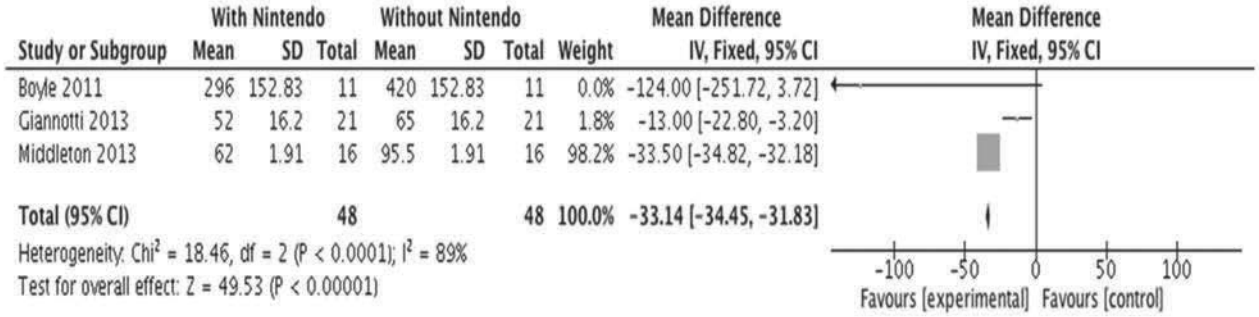

Figure 4. Forest Plot of Comparison: Effect of training with Nintendo® Wii™ in eye-hand coordination task

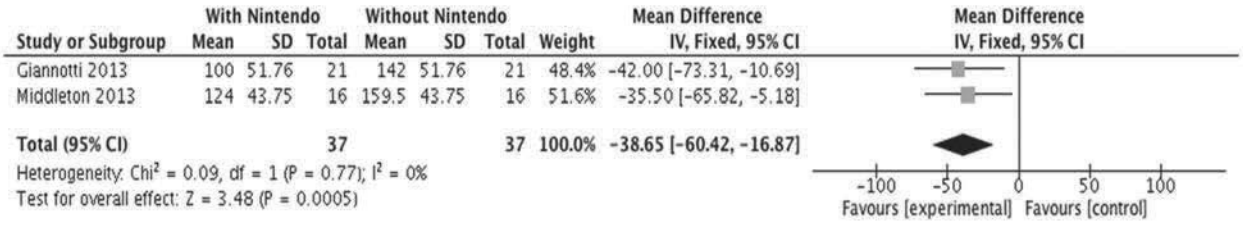

Figure 5. Forest Plot of Comparison: Effect of training with Nintendo® Wii™ in two-hand manipulation task

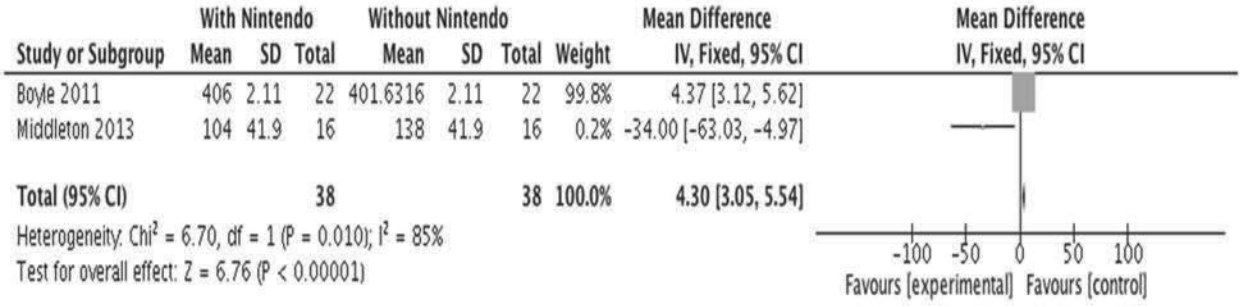

Figure 6. Forest Plot of Comparison: Effect of training with Nintendo® Wii™ in grasping, cutting or clipping task

manipulation or bimanual dexterity of laparoscopic novices. Training with Nintendo® Wii™, despite the different games used in the studies involved, contributed to the improvement of these basic laparoscopic skills since the gaming console of Nintendo® Wii™ has similar properties to the usual laparoscopic instruments used.[3] The Nintendo® Wii™ gaming console has computer graphics and interface that resembles that of a virtual laparoscopic simulator.[3] Furthermore, its console is a wireless remote controller that can be used as a handheld pointing device, which is able to detect movement in three dimensions. Unlike other available video games, the Nintendo® Wii™ is far from the traditional buttons or joysticks that other video game consoles provide.[4] Hence, its improvement from traditional video games contributed to its positive effect in the improvement of basic laparoscopic skills.

This review, however, was unable to fully reflect the effect of training with Nintendo® Wii™ on other tasks involved in laparoscopy such as grasping and cutting, or grasping and clipping. These important skills in laparoscopy are usually employed in certain laparoscopic procedures, such as laparoscopic appendectomy and laparoscopic cholecystectomy. It only shows that more studies are needed to determine the effect of Nintendo® Wii™ in these laparoscopic skills. It also suggests that the games involved in Nintendo® Wii™ may not be capable to address these laparoscopic skills involved. Hence, other training tools might be needed in the training for advanced skills in laparoscopy.

To further strengthen the effect of training with Nintendo® Wii™ on laparoscopic skills, more uniform studies must be done. The duration and frequency of training must be precise and similar among participants. The type of game to be used while training with Nintendo® Wii™ must also be similar among the study groups. Jalink M, et al. have concluded that the first video game and custom-made hardware called "Underground" is an acceptable game to both expert and novice laparoscopic surgeons. It is the first gaming console that is realistic and comparable with normal laparoscopy.[5] Hence, this video game can be further evaluated in its benefit in laparoscopic training.

To better evaluate the performance of novices after training with Nintendo® Wii™, a laparoscopic simulator is still recommended as used in the studies involved. This will not only decrease biases, but the performance of each trainee can be more evaluated or analyzed objectively. This is so since other than the measurement of time to completion of one task, simulators also compute for the number of movements, path length and economy of movement of each hand. Hence, speed and accuracy for each hand can be analyzed. Some laparoscopic simulators are also capable of measuring the time to completion of a certain laparoscopic procedure, such as virtual laparoscopic cholecystectomy.

Conclusions

This review was able to show that training with Nintendo® Wii™ was able to improve both eye-hand coordination and two-hand manipulation by laparoscopic novices. This shows that Nintendo® Wii™ can be used as a training tool for surgical residents in training hospitals or centers that cannot afford the usual laparoscopic simulators or box trainers. Hence, with the advent of minimally invasive surgery, training with Nintendo® Wii™ can be used as an adjunct in the training of novices in the use of laparoscopy.

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