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Nonsurgical abilities predict laparoscopic surgical skills after training

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ABSTRACT

It has been suggested that certain nonsurgical abilities can be used to predict laparoscopic surgical skills. This study aimed to conclusively determine whether these nonsurgical proficiencies are associated with laparoscopic surgical skills both before and after surgical training. We recruited 58 medical students for this study and assessed their laparoscopic surgical skills using the Surgical Assessment Device (HUESAD). The participants performed ten runs of HUESAD tasks before training. After they underwent box training and VR simulator training once a week for two weeks, they performed ten additional runs of the tasks. Finally, the participants responded to a questionnaire about their involvement in nonsurgical skills, including playing computer games, typing, sewing, playing musical instruments, and using chopsticks. Pearson's correlation coefficients were calculated. No significant correlation was found between any of the nonsurgical skills and initial laparoscopic surgical skills. However, a significant correlation was observed between the participants' ability to use chopsticks and scissors, ride a bicycle, and post-training laparoscopic surgical skills ($p < 0.05$). Several nonsurgical abilities investigated in this study did not correlate with pre- and post-training laparoscopic surgical skills, demonstrating that certain nonsurgical skills predict laparoscopic surgical skills not before but after training. This approach can be useful in predicting improvement in laparoscopic surgical skills. The ability to predict laparoscopic surgical skills is important for designing custom training programs to ensure safety and high-quality operations in laparoscopic surgery.

Key words: *Laparoscopic surgery*, *Surgical education*, *Training*, *nonsurgical skills*, *Hiroshima University Endoscopic Surgical Assessment Device (HUESAD)*

INTRODUCTION

Establishing training and education systems for laparoscopic surgery is necessary to ensure safety and the high quality of operations. It is imperative to predict laparoscopic surgical proficiency to design custom training programs. Many previous studies have attempted to predict laparoscopic surgical skills, and several studies have reported that specific nonsurgical skills may predict the laparoscopic surgical skills of medical students. For example, a few studies predicted laparoscopic surgical skills based on the participant's ability to use chopsticks[1)] and play musical instruments[1,17)]. While some studies have suggested that video game experience can predict baseline laparoscopic surgical skills[4,8)]. Moreover, mini-interviews on medical students' nonsurgical skills (including questions such as "Do you like video games?" and "Do you have confidence in your ability to drive?") have been reported to predict laparoscopic surgical skills[14)]. These studies suggested that nonsurgical skills predict laparoscopic surgical skills.

However, the results of these studies are inconsistent. For example, while a previous study revealed that initial laparoscopic surgical skills cannot be predicted by video game usage[11)], another study found that nonsurgical skills such as typing, playing computer games, sewing, and playing musical instruments do not predict the initial scores in box trainers and/or virtual-reality trainers[12)]. The exact reasons for this discrepancy remain unclear. One possible explanation is that researchers may have studied the correlation of nonsurgical skills with initial pre-training skills alone. Compared to open surgery, laparoscopic surgery signifies a more challenging learning process in terms of sensory input, spatial perception[13)], hand-eye coordination, tactile feedback, and the fulcrum effect of long instruments[9)]; thus, the initial performances of laparoscopic surgery are unstable. To accurately predict a surgical trainee's talent in laparoscopic surgery, it would be necessary to investigate performance curves during repetitive trials[15)]. Therefore, although nonsurgical skills might not predict laparoscopic surgical skills before training, they may predict post-training laparoscopic surgical skills. Another possi-

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ble explanation for the results of the previous studies is the relatively small sample sizes used. If a sample size is too small, it is difficult to tell whether a particular result occurred due to coincidence or as a result of the experiment.

This study aimed to determine whether nonsurgical skills are associated with pre- and post-training laparoscopic surgical skills. We used a large sample of students for this study and hypothesized that laparoscopic surgical skills after the training of novice surgeons could be predicted by nonsurgical skills.

MATERIALS AND METHODS

Participants

Fifty-eight medical students (17 women, mean age: 24.1 ± 1.1) were recruited for this study. All the participants were right-handed and were selected on the basis that they had no simulation or clinical experience performing laparoscopic procedures. This was the only eligibility factor; hence, there was no difference in interest in the aptitude for surgery in other areas. This study protocol was approved by the Committee for Experimentation at Hiroshima University (E2022-0314).

HUESAD

The construct validity of the Hiroshima University Endoscopic Surgical Assessment Device (HUESAD), a motion analysis system, has been demonstrated in a previous study[5,6]. HUESAD was designed based on the assumption that the orbits of the device reflect the surgeon's dexterity, and it was designed to precisely trace the movement of the tip of a laparoscopic instrument[7,18,19].

The task was to move the tip of the laparoscopic instrument on the tops of the poles from points A to C and C to A and from B to D and D to B (Fig. 1). The position of the scope is shown in Fig. 1. Each participant repeated the tests ten times using the dominant hand.

The orbit of the tip of the laparoscopic instrument and the time taken to perform the tasks were accurately recorded using a portable computer. To define the HUESAD assessment score, the deviation from the ideal course was measured and integrated with the time taken to move the instrument. Our previous studies demonstrated that the HUESAD assessment score was significantly lower for the expert group than that for the novice group[5,6]. Therefore, HUESAD was positioned as a reliable assessment system for laparoscopic surgical skills.

Procedure

The participants arrived at the laparoscopic surgical training center individually. They first read an information sheet describing the aims of the study and then provided their written informed consent for participation in the study; subsequently, they received an introduction to the HUESAD and performed HUESAD tasks (pre-training tasks). The participants then underwent box training (MC Medical, Inc., Tokyo, Japan) and training using virtual reality simulation tools, such as Lap Sim (Surgical Science, Göteborg, Sweden) and Laparoscopy VR (Immersion Medical, Gaithersburg, MD, USA). All these simulators provided tasks designed to train students in the basic surgical skills required for laparoscopic surgery. The participants were trained by performing various basic tasks. They trained once a week (2 h) for two weeks and then repeated the HUESAD tasks ten times (after training). After the procedure, the participants were given a questionnaire comprising questions about their nonsurgical skills.

Assessment of nonsurgical skills

All the participants were asked to respond to a questionnaire designed to determine whether they played computer games, sewed, played musical instruments, utilized chopsticks and scissors, and rode a bicycle

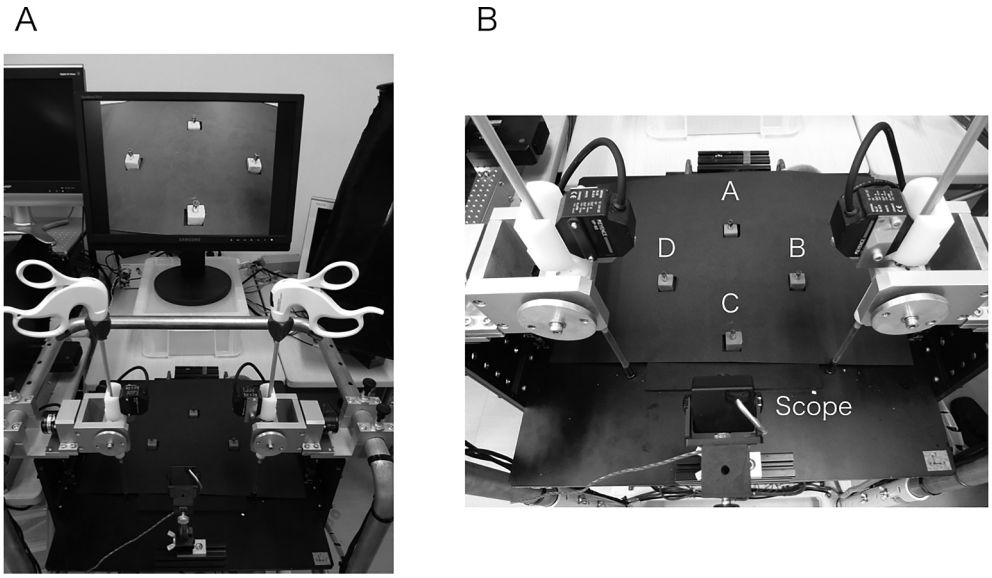

Fig. 1 A. The Hiroshima University Endoscopic Surgical Assessment Device. B. During the task, the tip of the endoscopic instrument was moved from pole A to pole C, pole C to pole A, pole B to pole D, and pole D to pole B. The position of the scope is shown.

Table 1 Questionnaire responses (n = 58)

Questions	Nonsurgical skills score
Do you like video games?	3.59 (1.4)
Do you sew (clothes, etc.)?	3.14 (1.1)
Do you play any musical instruments?	2.67 (1.2)
Are you confident about using chopsticks?	3.83 (1.0)
Are you confident about your ability to use scissors?	3.79 (1.0)
Do you feel confident about riding a bicycle?	3.90 (1.0)

Each response was scored on a Likert scale of 1 to 5. Data are presented as mean (SD)

Table 2 Correlations between nonsurgical skills and HUESAD assessment scores before and after training

Nonsurgical skills	Pre-training HUESAD assessment score		Post-training HUESAD assessment score	
	r value	p value	r value	p value
Do you like video games?	−0.147	0.269	−0.236	0.050
Do you sew (clothes, etc.)?	0.080	0.951	−0.172	0.196
Do you play any musical instruments?	0.099	0.459	0.179	0.178
Are you confident about using chopsticks?	0.120	0.928	−0.432*	< 0.001
Are you confident about your ability to use scissors?	−0.079	0.555	−0.312*	0.017
Do you feel confident about riding a bicycle?	−0.211	0.111	−0.350*	0.007

* $p < 0.05$

(Table 1). This questionnaire was created based on previous research, which had indicated that non-surgical skills predicted trainee's skills in surgical simulation. In this study, questions were presented using a 5-point Likert scale, ranging from 1 (not at all) to 5 (very much).

Statistical analysis

Statistical analysis of the data was carried out using IBM SPSS Statistics for Windows (Armonk, NY: IBM Corp.). The difference in the HUESAD assessment scores obtained at the pre- and post-training evaluations was examined using the Wilcoxon signed-rank test. Spearman coefficients were calculated to assess the nonsurgical skills and HUESAD assessment scores (both pre- and post-training scores). The effect size was shown using the r value for the Wilcoxon signed-rank test. Effect sizes provided a measure of the "meaningfulness" of an effect, with 0.2, 0.5, and 0.8 generally used to represent "small," "medium," and "large" effects, respectively[2,3]. The level of statistical significance (α) was set at 0.05 or less. All results were expressed as means ± SEM.

RESULTS

HUESAD assessment scores

The HUESAD assessment scores significantly improved after training (before: 96.2 ± 4.2 mm·s, after: 60.5 ± 3.5 mm·s, $p < 0.001$, $r = 0.83$; Fig. 2).

Correlations between nonsurgical skills and laparoscopic surgical skills

The nonsurgical skill scores of the participants are presented in Table 1. No significant correlation was observed between all the nonsurgical skills and the pre-training HUESAD assessment scores (Table 2). However,

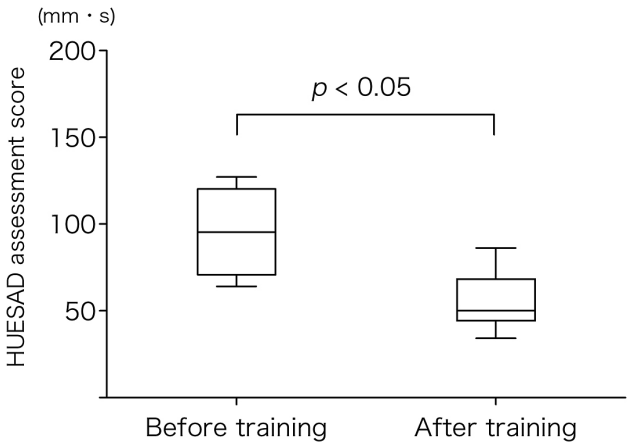

Fig. 2 HUESAD assessment scores obtained before and after training. The HUESAD assessment scores were significantly higher after training ($p < 0.05$).

there was a correlation between post-training HUESAD assessment scores and nonsurgical skills, such as using chopsticks and scissors and riding a bicycle ($r = -0.432$, $p < 0.001$; $r = -0.312$, $p = 0.017$; and $r = -0.350$, $p = 0.007$ respectively, Table 2). Furthermore, post-training HUESAD assessment scores and sewing, musical instrument playing, and video game playing were not correlated.

DISCUSSION

Specific nonsurgical abilities may predict laparoscopic surgical skills; however, these results are inconsistent. The purpose of this study was to determine whether these nonsurgical skills are associated with laparoscopic surgical skills not before training but after training. We studied a large sample of medical students (N = 58). The results of this study demonstrate a correlation between

nonsurgical skills and the score on HUESAD after training.

Laparoscopic simulations have been used as tools for practice and the assessment of laparoscopic surgery. The HUESAD is an assessment device that can precisely follow the movement of the tip of a laparoscopic instrument; thus, it can provide information regarding the surgeon's dexterity, which is an important parameter in the assessment of laparoscopic surgical skills. In this study, virtual reality simulator training and box training significantly improved the HUESAD assessment scores. Our approach using the HUESAD system can be considered valid and reliable.

Madan et al.[12] reported that nonsurgical skills such as typing, playing computer games, sewing, and playing musical instruments do not predict the initial scores of inanimate box or virtual-reality trainers. Our results demonstrated no significant correlations between the pre-training HUESAD assessment scores and nonsurgical skills such as playing computer games, sewing, playing musical instruments, using chopsticks and scissors, and riding a bicycle. In this aspect, our results are consistent with the findings of Madan et al.[12]. Currently, laparoscopic surgical techniques are the gold standard in many surgical procedures, but they entail considerable difficulty in the learning process. Therefore, since the performance of initial laparoscopic surgical skills might not be stable, it is difficult to predict them.

In contrast to the pre-training HUESAD assessment score, the post-training score correlated with using chopsticks and scissors and riding a bicycle. Thus, these findings validate our hypothesis that the laparoscopic surgical skills of novice surgeons, after they undergo training, can be predicted by certain nonsurgical abilities. The participants were trained by performing various basic surgical tasks to develop their laparoscopic surgical skills. Hence, these post-training skills are relatively more stable than the initial performance before any training.

Laparoscopic surgery involves using long instruments inserted through small ports on the body, depriving surgeons of the sense of touch (haptics), spatial perception, manual dexterity, and hand-eye coordination that they are accustomed to availing of during open surgical procedures. In this study, the ability to use chopsticks and scissors and ride a bicycle were found to be predictors of improved laparoscopic surgical skills following training. The abilities associated with using chopsticks and scissors are akin to the skills required in laparoscopic surgery, especially regarding the manual dexterity required in handling long instruments. A previous study demonstrated that factor analysis showed that the skill required for chopstick manipulation should be categorized as the "dexterity" component[2].

In the field of laparoscopic surgery, Nomura et al.[14] demonstrated that medical students who were confident about driving completed their laparoscopic virtual reality simulator tasks in less time. However, it was not necessary that all students have driver's licenses, because in this study, we assessed the participants' ability to ride a bicycle. Our result demonstrated that the ability to ride a bicycle predicted laparoscopic surgical skills after training. Therefore, the ability to use chopsticks and scissors and ride a bicycle require abilities similar to those used in laparoscopic tasks. Furthermore, these nonsurgical tasks may play a role in the acquisition or augmentation of skills of manual dexterity and spatial perception required for laparoscopic surgery.

The finding of the correlation between laparoscopic surgical skills and gaming experience agrees with those of certain previous studies[8]. Rosser et al.[16] tested laparoscopic and suturing skills in their study subjects. The participants in the top tertile of the video game score performed significantly better than those in the bottom tertile when scored for time and number of errors on the laparoscopic skill program. Previous studies that employed the questionnaire-based assessment method reported that both current and past gamers scored better on the laparoscopic simulator[10]. However, our results show that playing video games did not correlate with pre- and post-training laparoscopic surgical skills. In our questionnaire, we asked the students whether they liked to play video games. It is suggested that this questionnaire may have been insufficient for predicting laparoscopic surgical skills.

A limitation of the present study is that the nonsurgical skills assessed were based on a self-report questionnaire rather than an objective assessment of actual skills. This means that participants' self-perception and self-confidence may have influenced their responses and, therefore, the study results. Hence, the correlation between these self-reported non-surgical skills and post-training laparoscopic surgical skills should be interpreted with caution. It would be valuable for future studies to include objective assessments of these non-surgical skills to measure their influence more accurately on the acquisition of laparoscopic surgical skills.

Another limitation relates to the design of the questionnaire itself. The items used were created with reference to several previous studies and combined questions about participants' preferences or activities (e.g., "Do you like video games?", "Do you sew (clothes, etc.)?", "Do you play any musical instruments?") with those assessing confidence in specific skills (e.g., "Are you confident in using chopsticks?", "Are you confident in your ability to use scissors?", "Are you confident in riding a bicycle?"). This discrepancy could lead to confounding measures of liking or doing an activity with confidence in the related skills, thereby affecting the interpretation of results.

In future research, it would be beneficial to maintain a consistent approach to question framing to avoid such confusion. For example, all questions should be framed to measure either participants' preference or their confidence, such as "Do you feel confident in playing video games?", "Do you feel confident in your ability to sew?", "Do you feel confident in your ability to play a musical instrument?". Implementing such a change would align all questions along a common dimension, providing a more homogeneous set of responses for analysis.

CONCLUSION

This study demonstrates that non-surgical skills such as using chopsticks and scissors and riding a bicycle predict laparoscopic surgical skills not before but after training. This approach may be useful in predicting improvement in laparoscopic surgical skills. The ability to predict these skills is important for designing individualized training programs in safety and high-quality surgery. The advantages of the questionnaire method were that it was quick and easy to administer, and it was possible to obtain a large amount of information in a short time. Therefore, such tests may help to quickly, easily, and accurately identify trainees who will benefit from training in laparoscopic surgery.

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