

## Assessment of Obstetrician-Gynecologists Performing Laparoscopic Surgery: Study of Hand Size and Surgical Instruments

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### Abstract

The hypothesis of this study is that small-handed female obstetrician-gynecologists (OB/GYNs) experience more physical stress while performing laparoscopic surgery compared to large-handed OB/GYNs. The size and grip and pinch strength of surgeon's hands were measured and compared to the average size hands of females and males reported in the U.S. anthropometric literature databases on body dimensions. A descriptive questionnaire was administered to six OB/GYN surgeons (five females and one male) to obtain general background information, including personal work experience and musculoskeletal disorders symptoms (MSDs). Operating room assessment using Rapid Upper Limb Assessment (RULA), a standard ergonomic assessment tool, and photographs/video that recorded body postures and motions of the surgeons was performed to identify risk factors of work-related

MSDs. Primary findings from this study included:

1. Small-handed female OB/GYNs reported difficulty using laparoscopic instruments.
2. Small-handed female OB/GYNs experienced more physical stress according to RULA and questionnaire results while performing laparoscopic surgery compared to large-handed male and female OB/GYNs in this study.
3. Awkward postures tended to be more prevalent among smaller OB/GYNs as a function of surgical workstation layout and laparoscopic hand tools.

Based on the observation, laparoscopic instruments need to be reengineered to help reduce the physical stress for small-handed surgeons.

**Keywords:** Ergonomics; Laparoscopic instruments; Awkward postures; Musculoskeletal disorders; MSDs; OB/GYN; RULA

### Introduction

Ergonomic challenges in operating rooms are discussed more often today because laparoscopic surgery developed quickly in the 1990s [1-4]. Due to the nature of laparoscopic surgery, surgeons are operating with long stiff instruments through fixed entry points; this reduces the degrees of freedom (DOF) movement from "six" in open surgery to "four" in laparoscopic surgery. Subsequently, mechanical strength transfer (from the handles to the tips) decreases significantly: six times effort is required to finish the same task when using laparoscopic instruments compared to traditional tools [5]. To compensate for the loss of DOF and strength, stressful postures of the upper limbs become more common in surgeons when performing laparoscopy. In addition, surgeons tend to pay little attention to their body postures as more skill and concentration are required for laparoscopy.

Along with identifying ergonomic challenges, many work-related Musculoskeletal Disorders (MSDs) among surgeons were reported. Researchers throughout the world reported many MSD symptoms including eye strain, neck pain and stiffness, hand and wrist pain/stiffness/numbness, back pain and finger calluses. From an "e-mail" study of 317 laparoscopic surgeons in North America reported by Park et al., 272 (86.9%) of those performing such surgery reported physical symptoms of discomfort. This compares to the 20% to 30% incidence rate of occupational MSDs reported while performing traditional open surgery [6-8].

Such increased ergonomic risk might be contributed to factors such as inappropriate monitor location and improper height of the operating table. These instruments were considered important as they related to the surgeons' hand directly and affected their postures undoubtedly.

Specifically, several reports pointed out muscle exhaustion, pressure areas, neural injury, and rapid fatigue caused by instrument handles [9]. For example, the ring handles posed continuous pressure on the hand, thus resulting in numbness and tingling in the contact area, particularly on the thumb [10-12]; furthermore, non-neutral position of the hand introduced by using these handles caused loss of hand strength, thus speeding up the fatigue of muscles.

Anthropometric differences between males and females could be up to 30% in hand size, and the female hand typically has about 70% the strength of the male hand [13,14]. However, currently available laparoscopic instruments do not take these differences into consideration. A study by Adams et al. suggested that as residents' glove size increased, so did their level of reported ease with which they used laparoscopic instruments [15]. Also, women were more likely to use two hands in using disposable devices due to instrument size, which complicates the process of surgery. As a result, handles that are designed for the large male hand pose increased difficulty on the small female hand for holding and using these laparoscopic tools, thereby decreasing the work efficiency and increasing the risk of MSDs. Being

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a group that makes up about 70% of OB/GYN residents, females may face more physical stress due to the inappropriate size of laparoscopic instruments [16].

Most ergonomic assessments in the operating room do not discuss gender or specialty differences of surgeons. In addition, because of the difficulties in accessing an operating room, many studies are limited to simulation experiments or questionnaires and surveys. This study was conducted in an operating room at a hospital located in the Midwest, United States. The focus of this study was systematic onsite observation and recording of surgical practices, and ergonomic assessment on the OB/GYN as he/she performed during laparoscopic surgery. The results showed ergonomic risk for MSDs in this population.

## Methods

The protocol for this research study was approved by the Purdue University Institutional Review Board (IRB: 1106010960). Permission was granted to observe and document work-risk factors associated with MSDs during the performance of laparoscopic surgery at a local hospital near Purdue University. Six OB/GYNs participated in the study. Of the six surgeons, five were female and one was male, ranging in age from 31 to 55.

### Anthropometric measurements

The following anthropometric measurements were taken during the study: standing height, elbow height (standing), thumb-tip reach, four measurements of the hand (including length and breadth), hand force; grip strength; and pinch strength. Hand length was measured as the distance from the fold of the wrist to the tip of the middle finger; hand breadth was measured at the level of the metacarpophalangeal joints as the distance between the index finger and the little finger when fingers were abducted; hand force was measured as the maximum strength when the subject kept the upper limb close to the body and forearm and wrist at a neutral position (forearm is about 20 degrees below the transverse plane); hand grip strength was measured using a hand dynamometer (LAFAYETTE HAND DYNAMOMETER, 2004, Model 78010, Lafayette Instrument Company); and pinch strength by the JAMAR Hydraulic Pinch Gauge (Serial No. 50611002, 2000, Sammons Preston, Inc. Ability One). Each type of force (strength) was measured over three trials, and averaged to report one result. All the measurements were taken during the surgeon's patient consulting time -not prior- or post-surgery--to avoid bias in strength measurements.

## Questionnaire

A questionnaire consisting of twenty-four questions was distributed to the six OB/GYNs to assess their demographic characteristics, general workload, use of laparoscopic instruments, and musculoskeletal symptoms. It contained twenty-one multiple choice questions, two questions requesting a number to describe the fatigue level on a scale of 1 to 10, and one open question asking their thoughts about the laparoscopic instruments.

### Ergonomic assessment during laparoscopy performing

A standardized ergonomic assessment tool: Rapid Upper Limb Assessment (RULA) was used to evaluate potential MSD risks caused by awkward postures and motions while performing laparoscopic surgery [17,18]. In the RULA score system, postures of body parts are scored and combined in diagrams. Based on the final score, the posture guidelines are separated into four levels: "acceptable" (score 1-2), "further investigation" (score 3-4), "change soon" (score 5-6), or "change immediately" (score 7). Scores were obtained through direct observation and recorded with regard to specific tasks. Additional information was provided from photographs and videos that were taken to identify awkward postures during specific surgical tasks.

In this study five types of laparoscopic gynecological surgery processes were observed: laparoscopic supracervical hysterectomy, laparoscopic bilateral tubal ligation, laparoscopic assistant vaginal hysterectomy (LAVH), laparoscopic cystectomy, and diagnostic laparoscopy. Twelve types of tasks (Table 1) were recorded and assessed using the standardized ergonomic RULA tool.

## Results

This study collected anthropometric information for different surgical glove sizes. More important, the results showed that the assessed RULA score and self-reported fatigue level both indicated higher physical stress in surgeons with smaller glove sizes than those with larger glove sizes.

### Anthropometric results

The elbow height and thumb-tip reach were not correlated to the standing height in this sample. Though there was a trend that the taller subjects tended to have larger hands (longer and wider), the difference of hand length for two subjects with same standing height still could

Tasks <sup>A</sup>	Related Instruments	Definition of tasks
Puncture	Trocar	Inserting the trocar through skin into the abdominal cavity
Dissecting	Forceps, grasper	Separating tissue or organ at operating field using the blunt end of an instrument
Probing	Probe	Separating detached tissue or organ to explore operating field using the blunt end of probe
Ligation	bipolar forceps/ Ligasure	Detaching the uterus from its supporting structures with bipolar forceps/ Ligasure
Stapling	Stapler	Detaching the uterus from its supporting structures with stapler
Clip	Clip applicator, Forceps	Fixing the clip in the jaw of the instrument on fallopian tube
Grasping	Grasper	Grasping a tissue or organ with it inside the jaws of the instrument
Cut cautery	bipolar forceps	Separating tissue using bipolar forceps
Tying knot (inside)	Grasp, Laparoscopic knot pusher	Bringing disconnected tissue or squashing tissue together with suture thread
Tying knot (on skin)	-	Bringing disconnected skin tissue or subcutaneous tissue together with suture thread
Suturing (inside)	Needle holder, Forceps	Piercing of organ tissue with suture needle using laparoscopic needle holder
Suturing (on skin)	Forceps, needle holder	Piercing of skin tissue with the suture needle using traditional needle holder

<sup>A</sup>Refer to: Mehta et al. [18].

**Table 1:** Definition of observed surgical tasks and related instruments.

be as much as 0.7 cm. Generally, the dominant hands were longer and wider than the non-dominant, with the exception of one subject (dominant & non-dominant: 18.4 & 18.5 cm, respectively). The male hands were larger than the females, which is more obvious with regard to hand breadth. The grip force and key pinch force of all subjects were at about the average level of the male and female population reported before. A linear relationship was detected between the hand breadth and index finger key pinch strength in both left and right hand. (Left hand:  $R^2=0.8925$ , Right hand:  $R^2=0.819$ , Figure 1).

**Questionnaire results**

The six subjects, ages 31 to 55, are all trained in performing laparoscopic surgery and have from 4 to 29 years' experience performing laparoscopy. The dominant hand of all six subjects is the right hand. On average, the five female surgeons performed surgery one day per week, and the male surgeon performed surgery two days per week. The representative surgery time for one day was four to six hours, and only one surgeon (female) indicated less than two hours surgery time. Three of the surgeons took a rest break of less than 15 minutes, while the other three surgeons took a rest break of 15 to 30 minutes between two surgeries.

Of the six subjects in this study, three of them (two female and one male) had glove sizes of 6.5 or larger and reported the laparoscopic instruments were easier to use; the other three surgeons (glove sizes were 6.0 or less) found that these tools were harder to use. Their

anthropometric data are compared in Table 2. All subjects agreed that neck fatigue was most common after laparoscopic surgery; lower limbs, arms, hand and wrist fatigue were also mentioned. According to most subjects, the estimated level of fatigue after laparoscopic surgery was higher than that after open surgery.

Generally, the group with small glove sizes ( $\leq 6.0$ ) reported more fatigue than the group with large glove sizes ( $\geq 6.5$ ) in both laparoscopic surgery and open surgery (Figure 2). Specifically, the self-reported fatigue level after laparoscopy was related to the hand breadth. (Left hand:  $R^2=0.8769$ , Right hand:  $R^2=0.8517$ , Figure 3).

**RULA assessment on surgeons' postures**

In this study, the final RULA scores for each task were the average score of dominant and non-dominant hand. RULA scores varied from 2 to 6 (total range from 1 to 7). For 68% of the tasks it fell into the range of 3 to 4 and 16% of the tasks fell into the range 4 to 5. The guidelines from the RULA tool indicate that these scores merit further investigation to consider better postures for the surgeons. According to the anthropometric and questionnaire results, glove size was used to partition the surgeons' hand sizes into two different groups: hands with glove size  $\leq 6.0$  and hands with glove size  $\geq 6.5$ . The overall summary of these two groups suggested that the small glove size group got higher average RULA scores than the large glove size group (Figure 4). Specifically, when performing the same task, postures of large handed surgeons tended to have lower RULA scores compared to small handed

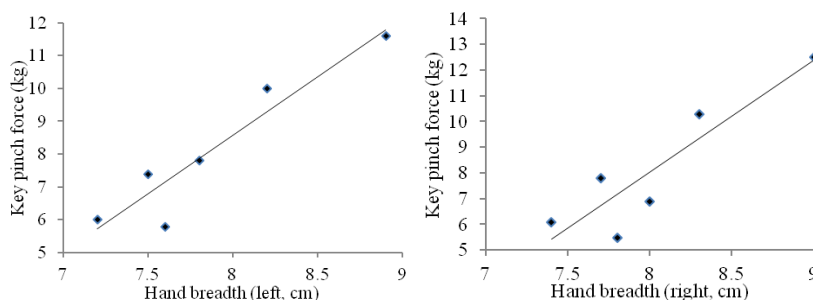


Figure 1: The variation of key pinch force (index finger) with different hand breadth.

Five Female Surgeons, One Male Surgeon.	Glove Size $\leq 6.0$ (n=3)		Glove Size $\geq 6.5$ (n=3)	
	Left	Right	Left	Right
Hand length (cm)	17 $\pm$ 0.52	17.3 $\pm$ 0.44	18.23 $\pm$ 0.38	18.36 $\pm$ 0.35
Hand breadth (cm)	7.43 $\pm$ 0.21	7.63 $\pm$ 0.21	8.3 $\pm$ 0.55	8.43 $\pm$ 0.51

Table 2: Comparison of hand anthropometric data between groups of surgeons with different glove sizes in this study.

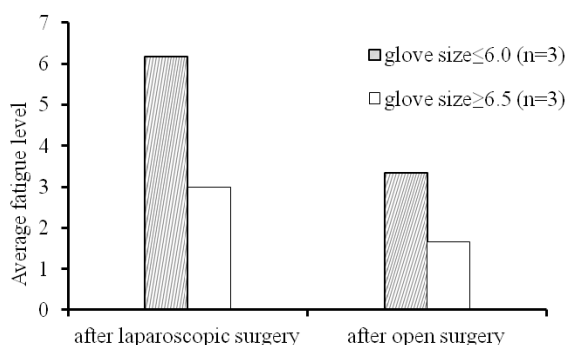


Figure 2: Comparison of average fatigue level between different glove size groups after open and laparoscopic surgery.

surgeons (Table 3). These findings suggest that surgeons with large hands had better postures, and experienced less physical stress than surgeons with small hands when performing the same laparoscopic tasks.

## Discussion

The use of hand tools can be a major contributing factor in producing workers' physical stress; they can affect the postures of the upper extremities. Additionally, hand size always needs to be a consideration when designing hand tools. Unfortunately, laparoscopic instruments are manufactured for one hand size only. Though some large laparoscopic instruments, such as the stapler, are documented as being too large for small-handed surgeons, there is no study to decide whether these instruments cause more physical stress, thus increasing risk of work-related MSDs. Therefore, this study was designed to test whether the small-handed OB/GYNs experience more physical stress when using laparoscopic instruments than large-handed OB/GYNs using both objective (RULA) and subjective (questionnaire) aspects. Furthermore, this study tried to introduce the anthropometric facts (instead of taking glove size alone) to make conclusions; this should be more practical and reliable. In this study, the OB/GYNs were grouped as glove size  $\leq 6.0$  and  $\geq 6.5$ , and anthropometric data showed that the average hand length and breadth between the two groups were quite obviously different.

In spite of limited sample size, this study showed that OB/GYNs who found laparoscopic instruments hard to use had an average

higher RULA score than those who did not experience difficulty while using the same instruments. Also, for the given tasks, large-handed OB/GYNs got average lower RULA scores than small-handed OB/GYNs. For individual surgeons, and all tasks, the male surgeon had the highest RULA score (3) which was less than that for the smallest female surgeon who had a score of 5. The reason for this difference, as documented by RULA, was that the male surgeon did not have to rotate his neck and head as much as the female surgeons to see the video monitor. This was because he was taller than the female surgeons. Also, he did not have to abduct his shoulders or raise his elbows over the operating table to perform routine surgical tasks (as the female surgeons did). For individual tasks, when the same task is performed in more complex laparoscopic surgeries, surgeons are more likely to experience higher physical stress than when the surgery is performed in simpler procedures.

According to the questionnaire, small-handed OB/GYNs experienced more fatigue after laparoscopy in comparison to their large-handed colleagues. Interestingly, the fatigue level was closely related to the hand breadth, which was most linearly regressed with the key pinch force of the index finger. If it is true that surgeons use their index finger most often during laparoscopic surgery, then possibly small-handed surgeons with less strength will get fatigued more easily, increasing their risk of MSDs. Moreover, strength is affected both by hand posture and grip opening, and grip strength is maximized within a narrow range of grip openings [19]. Therefore, when the grip opening of the instrument handle is too large for the hand, the hand will get fatigued more quickly.

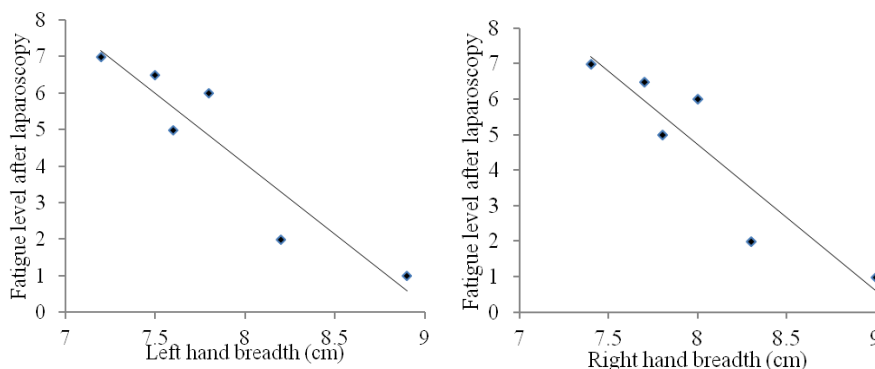


Figure 3: The variation of fatigue level after laparoscopy for OB/GYNs with different hand breadth.

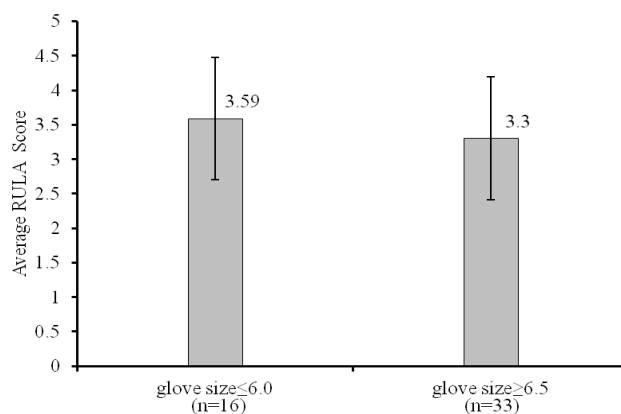


Figure 4: Comparison of average RULA score for all tasks between different glove size groups.

Tasks	RULA score	
	Glove size ≤ 6.0 (n=3)	Glove size ≥ 6.5 (n=3)
Puncture	3.4	3
Ligation	3.75	3.2
Probing	4	3.65
Suturing (on skin)	3.5	2.75

**Table 3:** Average RULA score of selected tasks for different glove size groups.

None of the six subjects claimed severe MSD symptoms currently. One reason for this could be that their surgical workload is not heavy. As indicated in Park's study, the strongest predictor of physical symptoms of discomfort is high case volume. Only two of the six surgeons attributed their MSD symptoms to their work, and their average RULA scores were 3.7 and 3.17. Four of the six subjects reported MSD symptoms, and three of the four belong to the small-handed group. The two surgeons who did not report specific MSDs had the lowest average RULA scores. These findings suggested that the RULA score could be a strong predictor for MSD risks. When asking about the experience of using these instruments, two rated the stapler as the most difficult instrument to use due to the handle size. One subject stated "it was hard to hold and adjust with the same hand." While this study focused on laparoscopic tools and hand size, it is consistent with other studies reporting ergonomic inconveniences for surgeons performing laparoscopic surgery [20,21].

## Conclusion

Laparoscopic tools are engineered to fulfill their function according to the task but are not balanced with the needs of the users. Based on this study, small-handed OB/GYNs, typically females, generally experienced higher physical stress and fatigue level when performing laparoscopic surgery compared to the large handed OB/GYNs, which is consistent with the fact that they found laparoscopic instruments harder to use than large-handed surgeons. Therefore, laparoscopic tools should be reengineered to provide small-handed OB/GYNs with proper sized laparoscopic instruments. This should be an efficient way to help to reduce the postural stress they suffer.

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