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ORIGINAL ARTICLE

Sitting versus standing makes a difference in musculoskeletal discomfort and postural load for surgeons performing vaginal surgery

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Abstract

Introduction and hypothesis We compared musculoskeletal discomfort and postural load among surgeons in sitting and standing positions during vaginal surgery.

Materials and methods Assessment of discomfort and posture of the primary surgeons in both positions was performed at two institutions. The primary outcome was an increase in body discomfort score after surgery as determined from subjective responses using validated tools. The secondary outcome was the percentage of time spent in awkward body postures measured objectively and stratified into awkward postures for neck, trunk, and bilateral shoulder angles. Variables were compared between sitting and standing positions using Fisher's exact test for primary outcomes and Wilcoxon rank-sum test for secondary outcomes.

Results Data were collected for 24 surgeries from four surgeons in sitting position and nine surgeries from nine surgeons in standing position. The standing surgeons reported a significant increase in discomfort postoperatively for bilateral wrists, thighs, and lower legs compared with the sitting surgeons. The median percentage of time spent in awkward postures was significantly lower for the trunk in the standing versus sitting position (median 0.3% vs 58.8%, $p < 0.001$) but was significantly higher for both shoulders in the standing versus the sitting position (right shoulder: median 17.8% vs 0.3%, $p = 0.003$; left shoulder: median 7.4% vs 0.2%, $p = 0.003$).

Conclusion Surgeons reported more discomfort in when performing vaginal surgery while standing. The postural load was worse for trunk but favorable for bilateral shoulders when seated. Such differences may impact a surgeon's decision to perform vaginal surgery seated rather than standing.

Keywords Ergonomics · Vaginal surgery · Musculoskeletal discomfort · Postural load

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Introduction

Surgeons have been historically subjected to work in unnatural postures or nonergonomic conditions for long hours [1, 2]. Working in a poor ergonomic environment results in occupational injuries, such as tenosynovitis, neuropraxic nerve injury, repetitive strain injury, carpal tunnel syndrome, vertebral disc, and cervical spine injury, all of which may reduce the surgeon's performance and career longevity [2–4]. There has been increasing evidence confirming the extensive prevalence of musculoskeletal disorders among surgeons performing open, laparoscopic, and robotic surgeries [4–7].

Up to 88% of gynecologists have reported musculoskeletal discomfort that may be attributed to performing surgeries [6–12]. Although vaginal surgery is the traditional way of performing many procedures in gynecologic surgery, there are limited data evaluating its impact on surgeon discomfort

and ergonomics [8, 10, 11, 13]. A survey-based study revealed that 87% of vaginal surgeons reported having musculoskeletal disorders: ~18% missed work, and 19% modified their practice by changing their work hours, type of surgery performed or the surgical technique [11]. A prospective trial evaluating the effect of different chair ergonomics during vaginal surgery revealed that 66% of surgeons experience bodily discomfort and are subjected to high-risk postures while operating in the sitting position [10]. Another prospective study evaluated and quantified the postural load for surgeons during vaginal procedures. The authors noted that surgeons were prone to significantly high postural load during vaginal procedures, especially vaginal hysterectomy [13]. Vaginal surgery is performed either in a sitting or standing position based on the surgeon's preference. However, there is lack of data exploring which of these positions may have an ergonomic benefit.

We compared musculoskeletal discomfort and postural load for surgeons in sitting and standing positions during vaginal surgery.

Methods

This was a retrospective analysis of data collected at two different institutions. Institutional review board approval was obtained at both institutions. Institution A used pre-existing data from a prospective randomized trial that evaluated the effect of different types of chairs on surgeon musculoskeletal discomfort and postural load [10]. During the study, surgeons' musculoskeletal discomfort and body postures were evaluated while they performed vaginal hysterectomy and reconstructive procedures for POP (POP). Surgeons were seated for all procedures and were assigned four different types of chairs. Subjective assessment of discomfort was performed using a validated body discomfort questionnaire, the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) [14], a graphic depiction of the Nordic Musculoskeletal Questionnaire [15]. Surgeons completed the questionnaire before and immediately after the surgery. Postural load was objectively measured in real time using wireless sensors in inertial measurement units (IMUs) (APDM Opals, Portland, OR, USA) [16]. These sensors were attached to the surgeons' head, trunk, and bilateral upper arms. Measured body angles were neck deviation from neutral (forward and lateral flexion/extension), trunk deviation from neutral (flexion/extension and lateral bending), and bilateral shoulder elevation (Fig. 1). Only data from surgeries where the surgeons used two similar chairs—round stool and round stool with backrest—were employed for this analysis.

At institution B, pre-existing data from a cross-sectional study evaluating musculoskeletal strain among primary and assistant gynecologic surgeons performing vaginal procedures were used. Data were collected while the surgeons performed total vaginal hysterectomy and pelvic reconstructive surgery involving apical suspension for POP whil in the standing position. The subjective assessment of body discomfort before and immediately after surgery was performed using a validated questionnaire, the Body Part Discomfort Interview BORG CR10® [17]. Surgeons' postural loads were measured using durations and frequencies of predefined awkward neck, trunk, and shoulder postures. Validated tablet-based ergonomic job analysis software, ErgoPART, was used to objectively measure the postural load in real time [13]. ErgoPART allowed observers to track in real time when awkward postures began and ended. These time measures were used to calculate the two measurements of postural load: duration and frequency of awkward postures. Comparisons between individuals observing the same surgeon during the same procedure indicated fairly high inter-observer reliability in the coding of body posture categories using ErgoPART [18]. A team of trained observers collected data in real time during the procedure. To provide visual cues for assessing awkward postures, surgeons were instructed to wear glasses and modified gowns with a cross-tape configuration on the nonsterile back (Fig. 1). Data were collected only on primary surgeons who stood during the entire procedure.

The primary outcome was the percent of procedures that increased surgeon discomfort postoperatively (based on response to validated questionnaires used in the respective studies) for both sitting and standing surgeons. The secondary outcome measure was the percentage of time spent in ergonomically awkward/high-risk body postures for neck, trunk, and bilateral shoulder angles. The definition of awkward for individual body parts was based on the following criteria [19–21] (Fig. 2):

- Trunk flexion: ≥20° (relative to the coronal plane)
- Trunk lateral bending: >20° (relative the midsagittal plane)
- Neck flexion or lateral deviation: ≥30° (relative to the trunk)
- Right shoulder flexion and/or abduction (elevation): >60° (relative to the trunk)
- Left shoulder flexion and/or abduction (elevation): >60° (relative to the trunk)

Variables were compared between sitting and standing positions using Fisher's exact test for primary outcomes and Wilcoxon rank-sum test for secondary outcomes. All calculated p values were two-sided, and p values <0.05 were considered statistically significant.

Results

Data were collected for 24 surgeries, with four primary surgeons in the seated position (Institution A) and nine surgeries

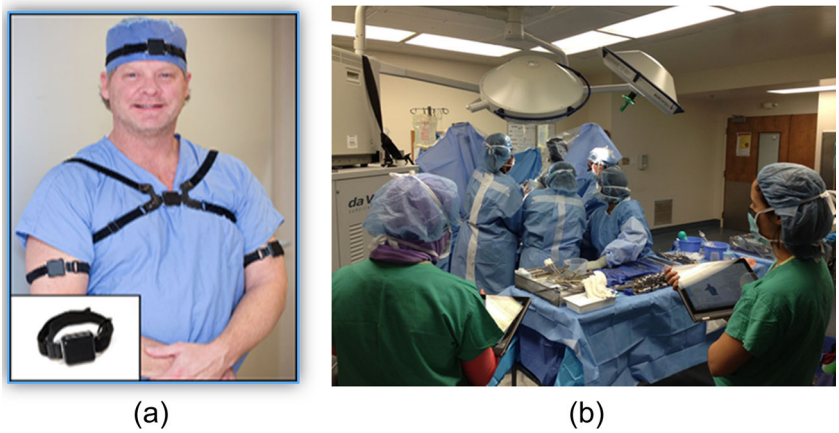

Fig. 1 **a** Surgeon wearing inertial measuring unit (IMUs) sensors to measure posture for sitting surgeons. **b** Surgeons' gowns were modified using a cross-tape configuration to provide visual cues for assessment of posture in standing positions

with nine primary surgeons in the standing position (Institution B). Of the 24 surgeries performed in group A, six were performed by each surgeon. Surgeries included vaginal hysterectomy, apical suspension, and pelvic reconstruction for POP. Demographic details of all surgeons are described in Table 1. All surgeons at Institution A were men; 77.8% (7/9) surgeons at Institution B were women Only 44.4% (4/9) of surgeons at Institution B were subspecialists, compared with 100% at Institution A. All surgeons were right-handed. Surgeons at Institution A (4; 100%) had more years of experience than those at Institution B (1; 11.1%), who had ≥10 years of experience. Most surgeons were never diagnosed with a musculoskeletal injury (0% at Institution A and 11.1% at Institution B). Three of the four surgeons (75.0%) at Institution A reported using nonprescription medications for pain compared with only one (11.1%) at Institution B. However, most surgeons in both groups reported seeking help for musculoskeletal discomfort, such as physical therapy, massage, chiropractic therapy, outpatient appointments, diagnostic testing, and referral to a specialist (4; 100% at Institution A and 8; 88.9% at Institution B).

Mean surgical duration was longer for standing surgeons (mean: Institution B: 191 ± 59 min vs. Institution A: 121 ± 21 min, $p < 0.001$). Seated surgeons used either the round stool with (12/24, 50.0%) or without (12/24, 50.0%) back rest. Standing surgeons experienced a significantly higher percent of surgeries with increased discomfort postoperatively (relative to before surgery) versus seated surgeons: wrists, thighs, and lower legs (right wrist: 33.3% vs 0%, $p = 0.02$; left wrist: 44.4% vs 0%, $p = 0.004$; bilateral thighs: 44.4% vs 9.1%, $p =$

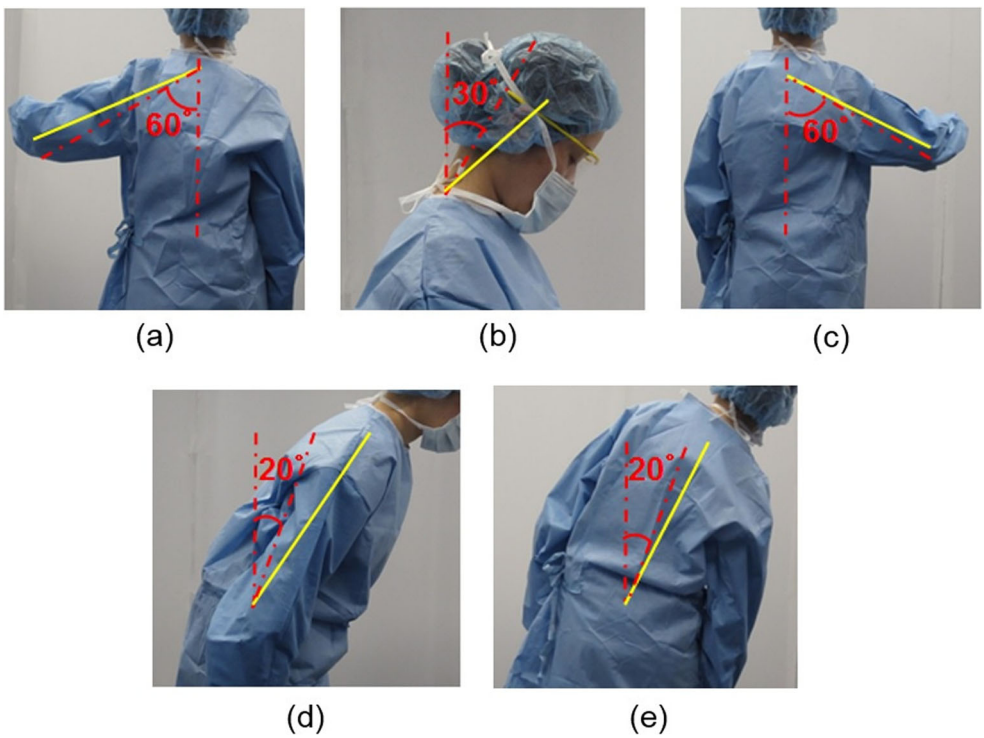

Fig. 2 Predefined awkward postures: **a** left shoulder flexion and/or abduction (elevation): > 60°. **b** Neck flexion or lateral deviation: ≥30°. **c** Right shoulder flexion and/or abduction (elevation): > 60°. **d** Trunk flexion: ≥20°. **e** Trunk lateral bending: >20°

Table 1 Demographic variables for participating surgeons

Characteristic	Institution A (sitting position) ($N = 4$) N (%)	Institution B (standing position) ($N = 9$) N (%)	P value*
Age (years)			0.13
20–30	0	2 (22.2)	
31–40	1 (25.0)	6 (66.7)	
41–50	3 (75.0)	1 (11.1)	
Gender			0.02
Male	4 (100.0)	2 (22.2)	
Female	0	7 (77.8)	
Race			0.99
Caucasian	3 (75.0)	5 (55.6)	
African American	0	1 (11.1)	
Asian	0	1 (11.1)	
Other	1 (25.0)	2 (22.2)	
Type of surgeon			0.10
General OB/GYN	0	5 (55.6)	
Subspecialist	4 (100.0)	4 (44.4)	
Dominant hand			–
Left	0	0	
Right	4 (100.0)	9 (100.0)	
Years of experience (including OB/GYN residency)			0.007
< 10	0	8 (88.9)	
≥ 10	4 (100.0)	1 (11.1)	
Prior musculoskeletal injury	0	1 (11.1)	0.99
Use of nonprescription pain medications	3 (75.0)	1 (11.1)	0.05
Access to medical help for pain	4 (100.0)	8 (88.9)	0.99

OB/GYN obstetrics and gynecology

*Fisher's exact test

0.04; bilateral lower legs: 33.3% vs 0%, $p = 0.02$ (Table 2). There was no difference in the percent of surgeries with increased surgeon discomfort postoperatively in the neck, upper and lower back, bilateral shoulders, bilateral elbows, and bilateral fingers/thumb among the two groups (Table 2). The median percentage of surgical time spent in ergonomically awkward body postures was significantly lower for trunk among standing vs sitting surgeons (median: 0.3% vs 58.8%; $p < 0.001$) (Table 3). However, the median percentage of time when each shoulder was in an awkward posture was significantly higher in standing vs sitting position (right shoulder: median 17.8% vs 0.3%, $p = 0.003$; left shoulder: median 7.4% vs 0.2%, $p = 0.003$, respectively) (Table 3).

The percentage of time spent in ergonomically awkward body postures for the neck, trunk, and bilateral shoulders during vaginal hysterectomy were compared between standing and sitting positions (Table 4). Median time spent with increased trunk flexion (flexion ≥20°) was significantly higher for sitting surgeons (median: 22.9% vs. 1.6%, $p < 0.001$). The percentage of time spent in ergonomically awkward body postures for the neck and bilateral shoulders was not different between groups.

Discussion

Surgeons reported an increase in musculoskeletal body discomfort after performing vaginal surgery for both sitting and standing positions. The literature demonstrates that vaginal surgeons report increased discomfort most commonly in the neck, upper and lower back, and bilateral shoulders [8, 10, 11]. Limited evidence also suggests that the postural load/musculoskeletal strain for these surgeons is high for the neck and bilateral shoulders [10, 13]. In our study, standing surgeons reported a significantly higher percent of increased discomfort postoperatively in bilateral wrists, lower legs, and thighs compared with sitting surgeons. Our findings are comparable with other studies performed in office-based settings for other professionals. These studies suggest that standing is associated with more discomfort than sitting in the entire lower body, especially the feet [22–25]. Prolonged standing at work has also been shown to be associated with health problems, such as chronic venous insufficiency, discomfort in the low back and lower extremities, and increased complications during pregnancy [3]. Furthermore, standing in a "fixed" posture is associated more frequently with lower back pain than standing with freedom to sit at will [25]. Although sitting was better than standing in these studies, a nonergonomic sitting posture has been associated with back pain and an increase in intradiscal pressure [26]. Working in a seated position with arms and back unsupported is associated with discomfort in back, shoulders, and upper extremities [27]. Individuals working in a fixed sitting position (without intermittent breaks) have increased back discomfort compared with those who take breaks intermittently [25]. Studies on ergonomics of surgeons performing robotic surgery in a seated position and have demonstrated an increased musculoskeletal strain for trunk and neck [28]. Similarly, limited data evaluating surgeons performing vaginal surgery in a seated position confirmed an increase in musculoskeletal strain for the neck and trunk [10].

Despite our observation of worse postural load for the trunk among sitting surgeons, the percent of surgeons who reported increased musculoskeletal discomfort in upper and lower back postoperatively was similar for both sitting and standing surgeons. Similarly, the percent of surgeons who reported increased musculoskeletal discomfort postoperatively in bilateral shoulders was similar in both positions despite evidence of worse postural load for standing surgeons. These findings may be a result of the smaller sample size of our study population. The standing surgeons experienced a significantly

Table 2 Increase in postoperative discomfort from baseline between the sitting and standing positions

Body part	Increased discomfort, *N* (%)		*P* value**
	Sitting (*N* = 22*)	Standing (*N* = 9)	
Bilateral lower legs	0 (0.0)	3 (33.3)	0.02
Bilateral knees	0 (0.0)	2 (22.2)	0.08
Bilateral thighs	2 (9.1)	4 (44.4)	0.04
Left fingers/thumb	3 (13.6)	3 (33.3)	0.32
Left wrist	0 (0.0)	4 (44.4)	0.004
Left elbow	0 (0.0)	2 (22.2)	0.08
Left shoulder	3 (13.6)	3 (33.3)	0.32
Right fingers/thumb	1 (4.5)	3 (33.3)	0.06
Right wrist	0 (0.0)	3 (33.3)	0.02
Right elbow	0 (0.0)	2 (22.2)	0.08
Right shoulder	6 (27.3)	3 (33.3)	0.99
Lower back	9 (40.9)	4 (44.4)	0.99
Upper back	5 (22.7)	2 (22.2)	0.99
Neck	1 (4.5)	2 (22.1)	0.19

*Validated instrument not completed for two of the 24 surgeries, **Fisher's exact test

higher percent of increased discomfort in the bilateral wrists. Sitting surgeons used a pad to place some of the instruments in their lap during surgery, which may have contributed to the less discomfort noted in this cohort compared with standing surgeons. Work-related hand and wrist discomfort may arise from the intensity of hand or finger exertion and frequency and/or duration of sustained awkward wrist positions. However, data for wrist postures and hand exertions during surgery were not collected, and the effects of potential confounding variables such as length of surgery, surgical procedures, and surgeon's age and experience could not be assessed due to limitations in study design.

Various interventions, such as compression stockings, floor mats, shoe inserts, scheduled breaks, and sit–stand working stations have been shown to be effective in reducing health hazards among different professions due to poor ergonomics

Table 3 Postural load between sitting and standing positions for the entire procedure

Body part	Time in awkward posture (%), median (IQR)		*P* value*
	Sitting (*N* = 24)	Standing (*N* = 9)	
Neck	43.2 (20.4, 65.0)	26.8 (18.3, 35.9)	0.23
Trunk	58.8 (23.7, 93.3)	0.3 (0.1, 1.6)	<0.001
Right shoulder	0.3 (0.1, 9.0)	17.8 (5.7, 30.2)	0.003
Left shoulder	0.2 (0.0, 1.8)	7.4 (4.0, 10.0)	0.003

IQR interquartile range

*Wilcoxon rank-sum test

Table 4 Postural load between sitting and standing positions for vaginal hysterectomy

Body part	Time in awkward posture (%), median (IQR)		*P* value*
	Sitting (*N* = 24)	Standing (*N* = 9)	
Neck	57.0 (23.5, 81.3)	45.1 (24.5, 56.6)	0.50
Trunk	22.9 (6.5, 40.4)	1.6 (0.0, 1.7)	<0.001
Right shoulder	18.8 (9.3, 33.2)	28.2 (9.6, 37.2)	0.41
Left shoulder	17.5 (8.4, 32.7)	10.0 (8.8, 16.5)	0.22

IQR interquartile range

*Wilcoxon rank-sum test

[3]. Among surgeons, intraoperative breaks, floor mats, ergonomic chairs, and shoe inserts have been evaluated in improving ergonomics in the operating room [29, 30]. Findings from our study emphasize the need for interventions for improving ergonomic deficits unique to both seated and standing surgeons. Overall sitting surgeons were less likely to report increased discomfort postoperatively, making it more favorable than the standing position.

This study compared ergonomic benefits of the surgeon sitting or standing during vaginal surgery, which not been evaluated previously. The study benefits from validated instruments for assessing musculoskeletal discomfort (CMDQ for sitting surgeons; BORG CR10® for standing surgeons), objective assessment of postural load (IMUs for sitting and observation-based ergonomic posture assessment software for standing) and data collection in real time. However, the major limitation of this study is that it compares retrospective data compiled at two different institutions using different methodology and instruments. Other limitations are the small number of cases and the presence of confounders, such as different surgical setup at each institution, the sequence of index surgery, and the presence of non-work-related musculoskeletal discomfort among surgeons. The longer surgical duration endured by standing surgeons may have contributed partly to the increased body discomfort. We were unable to assess the independent effects of surgery duration, position (sittings/standing), gender, and surgeon experience due to the inherent difference among cohorts. Group A (sitting position) consisted of four male surgeons with ≥10 years of experience; Group B (standing position) consisted of seven female surgeons with <10 years of experience, one male surgeon with <10 years of experience, and one male surgeon with ≥10 years of experience. Furthermore, for 23 of the 24 surgeries in Group A, duration of each surgery was less than the shortest surgery in Group B. Further study involving a more similar group of surgeons in each position is needed to evaluate the independent effects of these factors. We suggest a multicenter study using the same metrics to conclusively determine the most appropriate ergonomic approach to vaginal hysterectomies.

Conclusion

Surgeons reported more discomfort while operating in the standing position during vaginal procedures compared with a sitting position. The standing surgeons also spent significantly more time in awkward shoulder positions but significantly less time in awkward trunk positions. Such differences may influence the surgeon's decision to choose an appropriate ergonomic position while performing vaginal surgery.

Compliance with ethical standards

Conflicts of interest Ruchira Singh: None.
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