Ergonomics in Urology: Current Landscape and Future Directions

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Optimal ergonomics are essential to improving clinical performance and longevity among urologists, as poor ergonomics can contribute to work-related injury and physician burnout. While a majority of urologists experience muscular injury throughout their career, women and trainees are disproportionately affected. These disparities are exacerbated by the lack of formal ergonomics education within urologic training programs. This review provides an overview of practical approaches to optimize ergonomics across working environments for urologists and trainees. We highlight intraoperative techniques and novel devices which have been shown to reduce work-related injury, and we identify knowledge gaps to guide future areas of ergonomic research. UROLOGY 184: 235–243, 2024.

The field of surgical ergonomics has gained awareness in the last decade as the recognition of work-related injury among surgeons has increased. A majority of surgeons have reported experiencing pain due to operating, and nearly one-third have noted changes to their operative technique because of this pain.[1] Injury among surgeons can also contribute to physician burnout and even early retirement, which is of particular concern in urology, a field which has recently seen a worrisome increase in burnout amidst a looming workforce shortage.[2,3] Furthermore, the multifaceted nature of practicing urology creates unique challenges to maintaining optimal ergonomics across a variety of different environments and approaches.[4] Urologists regularly employ a diverse set of surgical skills including endoscopy, laparoscopy, robotics, microsurgery, and open surgery, each with their own ergonomic challenges. In one survey study, 86% of urologists reported musculoskeletal discomfort within the past year, most of which was believed to be secondary to their profession.[5] These problems can develop early in one's career, as 90% of surgical residents report musculoskeletal symptoms since starting their training.[6]

This narrative review summarizes what is known to improve and optimize surgical and office-based ergonomics for the practicing urologist and trainee. We describe the morbidity associated with practicing urologic surgery, and highlight innovations and novel technologies in the field of surgical ergonomics that have the potential to enhance ergonomic wellbeing. Finally, we identify areas where data are absent or lacking, in an effort to guide future study.

MATERIALS AND METHODS

A literature search in MEDLINE (via PubMed) was undertaken to identify published materials describing or assessing surgical ergonomics in urology and other surgical fields. Terms used in the search included combinations and variations of the following concepts and Medical Subject Headings (MeSH): urology, ergonomics, surgery, ambulatory care, posture, innovation, technology, education, work-related musculoskeletal disorders, microsurgery, endoscopic surgery, robotic surgery. Additional searches were performed as needed to identify articles related to specific topics uncovered during the primary search, such as mental fatigue, task load, cognitive workload, microbreaks, inertial measurement units (IMUs), electromyography (EMG), anti-fatigue mat, exoscope, flexible ureteroscopy, exoskeleton, patient positioning, surgical instruments, and loupes. Studies included primary literature, review articles, meta-analyses, and published abstracts. Articles identified were assessed by two authors (AK, HVP) for relevance to what is known about surgical and office-based ergonomics in urology, as well as future innovations and technologies in urologic ergonomics. Strict inclusion criteria were not explicitly used due to the heterogeneity of articles and topics. Articles were excluded if they were not written in the English language or if they were published before 2000. Particular attention was paid to clinical trials, larger studies, those specific to unique challenges of urology, and data collected within the past 5 years.

RESULTS AND DISCUSSION

Surgeon Morbidity From Performing Urologic Surgery

Performing urologic surgery is a physically and mentally demanding practice which often takes a toll on physicians.

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An estimated 60%-90% of urologists experience work-related muscular pain during their career.[4] Morbidity to the surgeon most often manifests as musculoskeletal pain or injury to nerves, muscles, or joints, collectively referred to as work-related musculoskeletal disorders (WMSDs).[7] Areas most frequently affected are the neck and back (degenerative cervical or lumbar spine disease), shoulders (rotator cuff pathology), wrists and hands (osteoarthritis, carpal tunnel syndrome), and eyes (eyestrain).[4] Practicing urology takes a cognitive toll on surgeons as well. Mental effort or cognitive task load can be assessed using validated indices, such as the National Aeronautics and Space Administration Task Load Index (NASA-TLX), or using objective data such as electroencephalography, heart rate monitoring, or pupillary tracking.[8,9] Cognitive task load has been shown to have a dose-dependent relationship with burnout, where subspecialties with higher physician task load are at higher risk of physician burnout.[10] According to one national study assessing task load across more than twenty subspecialties using the NASA-TLX, urology ranked second highest.[10] Furthermore, cognitive and musculoskeletal demands have been shown to correlate, with a direct association seen between mental workload and WMSDs, though studies examining this relationship among urologists are limited.[8,9]

While a majority of work-related injuries are mild or moderate in severity, 29% of urologists describe significant discomfort from WMSDs.[11] Over two-thirds of urologists have used over-the-counter analgesics, 20% have sought noninvasive interventions, and 10% have required invasive treatments for work-related pain.[11,12] Worse still, 8%-12% of urologists have required a leave of absence, and 2% have retired earlier than anticipated due to WMSDs.[7,11] This time away from work elicits financial burden due to lost productivity, worsening the inherent medical costs associated with WMSDs. In the United States, WMSDs are estimated to cost nearly $50 billion annually across all sectors, however, this figure has not been evaluated among physicians or urologists specifically.[13] Moreover, with an impending shortage of urologists in the United States, increased burnout due to compromised physical or mental well-being could significantly exacerbate the deficit.[3]

Ergonomic Considerations for Urologic Surgery

Differences in patient positioning, surgical instruments, and operative posture create varying ergonomic challenges depending on a urologist's typical practice and case variety. As the prevalence and severity of work-related musculoskeletal injury varies by approach, there is significant heterogeneity in risk among practitioners. For instance, traditional laparoscopy and endourology have been reported to carry higher risk of injury compared to open surgery, likely due to prolonged periods of static posture and routine use of foot pedals leading to uneven weight-bearing in unnatural body positions.[5] In open surgery, the use of loupes and head-mounted lights has been associated with increased time spent in ergonomically unfavorable positions as well as surgeon-reported pain due to increased weight carried by the surgeon's neck.[14] Similarly, lead aprons add additional weight which increases low back pain.[15] Patient transfer is another source of WMSD among surgeons across clinical settings, particularly when assisting obese patients or those with limited mobility.[16]

Much has been published regarding the optimal ergonomics of intraoperative posture, positioning, and equipment layout, examples of which are depicted in Figure 1.[4,17,18] In general, the optimal surgical posture allows for arms to rest comfortably at the surgeon's side, slightly abducted and retroverted (less than 30°), with elbows bent between 90°-120°.[17] The head should remain upright, with neck flexion limited to under 15°.[4] If surgical loupes are worn, through-the-lens mounted loupes offer reduced cervical strain compared to front-mounted loupes, and lightweight materials for

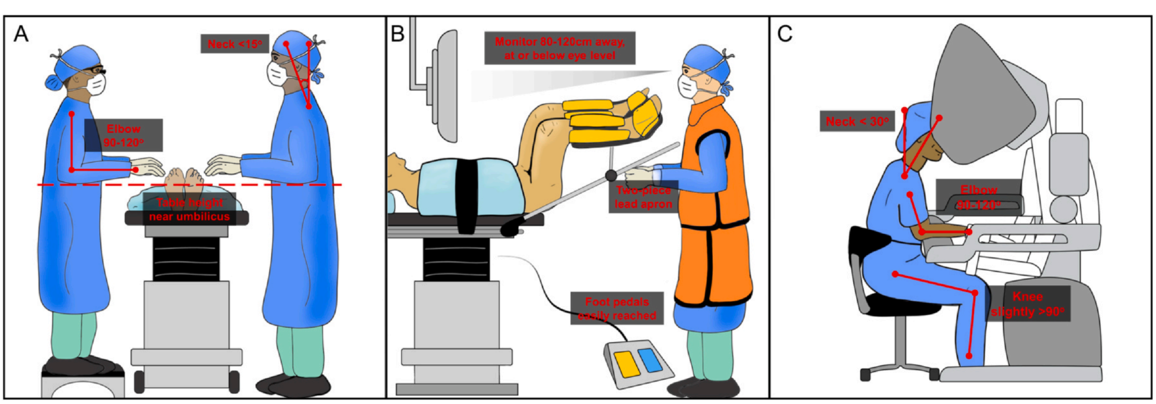

Figure 1. Optimal surgical posture for various operative approaches. **(A)** Open and microsurgery: arms rest comfortably at surgeon's side with shoulders abducted < 15°-30° and elbows bent 90°-120°. Head remains upright, with neck flexion limited to < 15°. Table height is at the level of the umbilicus. Lightweight through-the-lens loupes are preferred. **(B)** Endoscopic surgery: monitor is positioned 80-120 cm away from surgeon without requiring neck rotation, with the height at or slightly below eye level. Foot pedals should be easily reached. Two-piece lead aprons are preferred for better weight distribution. **(C)** Robotic surgery: height of chair is adjusted so that feet rest comfortably on ground with foot pedals positioned for knee angle slightly > 90°. A chair with lumbar support is preferred. Height of controls and viewing monitor is adjusted to allow for elbow angles 90°-120° and neck flexion < 30°. (Color version available online.)

frames and lenses should be prioritized.[17,19] When standing, the operating table should be near the level of the surgeon's umbilicus, allowing for arms to rest comfortably on the surgical field with elbow flexion of 90°.[18] In traditional laparoscopic surgery, the optimal table height is lower, with the insufflated abdomen near the level of the surgeon's pubic symphysis.[4] When using video monitors, screens should be positioned at or slightly below eye level, at a distance of approximately 80-120 cm from the surgeon, in order to avoid excessive cervical flexion and optical muscle strain.[17] If using intraoperative fluoroscopy, two-piece lead aprons are preferred due to a more ergonomic distribution of weight.[15,17] When operating while seated, the height of the chair should be adjusted so that feet rest comfortably on the ground. Foot pedals should be positioned such that the angle of the knee is slightly over 90°.[17] During robotic surgery, a chair with lumbar support is preferred. The height of the controls and the viewing monitor should be adjusted to the chair height, aiming for elbow angles between 90°-120° and neck flexion under 30°.[4] Judicious use of the clutch should be employed to avoid overextension of the shoulders, and care should be taken to avoid excess forward pressure on the head rest. When transferring patients, lower back injury should be mitigated through judicious use of assisting devices such as inflatable transfer sheets, patient sliding boards, or mechanical lifts.[16] Dissemination and application of these ideal ergonomic principles remains an understudied area.

In response to the ergonomic burden of operating, technologies have developed to help measure and quantify intraoperative strain. Wearable technology has evolved to include IMUs, which are sensors attached to the user's body that combine gyroscopic, accelerometric, and magnetometric data to accurately measure body position angles (Fig. 2).[14] One study using IMUs noted that urologists spend 56% of operating time with their neck in ergonomically high-risk positions, though these results were not stratified by surgical approach.[14] Another study which integrated IMU measurements with surgeon-reported pain found that urologists performing open surgery spent longer periods of time in ergonomically unfavorable postures and complained of more pain compared to those operating robotically.[20] While these technologies have yet to be widely implemented, there are commercially available IMU devices which may be utilized to optimize intraoperative ergonomics.[21] One such device is the Upright Go (Upright Technologies), a postural IMU which offers vibratory biofeedback when users are in ergonomically unfavorable positions, and has been shown to objectively improve ergonomic measures in otolaryngologists during tonsillectomy.[22] Studies using such technologies within urology are lacking.

Optimizing Outpatient Ergonomics

The ergonomics of office-based procedures have been scantly addressed in the urologic literature, though the area has been studied extensively in other surgical fields.[23,24] Comfortable and sustainable posture can be challenging during office-based procedures, as facilities are often designed for other, nonprocedural clinical situations. Lower back strain can be especially burdensome in the office setting, where beds are often wider with more limited adjustments compared to an operating table, requiring the physician to lean over the patient in ergonomically unfavorable postures.

With the ubiquity of electronic health record systems, nearly half of a physician's work hours are spent on documentation.[25] One survey of urologists reported that 75% of physicians felt they had insufficient time for documentation in the office, and 64% spent excessive amounts of time documenting at home.[26] Repetitive movements associated with typing and use of a mouse have been linked to musculoskeletal disorders of the hand, wrist, and forearm; wrist extension greater than 20° increases risk of carpal tunnel syndrome, and typing with an inner elbow angle less than 120° increases arm pain.[27] Similar to seated procedures, sitting while typing or using the electronic health record puts providers at risk for musculoskeletal symptoms of the lower back. Emphasis on good posture with lumbar support and adoption of ergonomic interventions such as standing computer workstations can help to decrease this risk.[28] With the ubiquity of documentation outside of the workplace, providers should consider optimizing ergonomic environments at home – potentially subsidized by employers at mutual benefit.

Intraoperative Ergonomic Interventions

Microbreaks. In addition to optimizing posture and positioning during operations, surgeons across specialties have implemented a variety of other intraoperative measures that may decrease musculoskeletal injury. Microbreaks are short pauses, typically less than 1-2 minutes in duration, which are taken every 20-40 minutes during a task requiring prolonged attention, and have demonstrated reductions in fatigue and musculoskeletal discomfort.[29] Recent data has shown that the use of microbreaks in the operating room increases mental focus and physical performance of the surgeon.[30,31] One study which tested surgeons' accuracy in cutting out a shape with Metzenbaum scissors found a seven-fold decrease in errors among surgeons who took microbreaks compared to those who did not.[29] A survey study of surgeons across a variety of specialties, including urology, found significant reductions in shoulder and hand pain, as well as a 57% improvement in self-reported physical performance after the introduction of microbreaks during surgery.[30] Another study showed similar improvements in neck, lower back, and extremity pain after taking microbreaks, with 57% of surgeons reporting improved physical performance and 38% reporting improved mental focus.[31] Notably, neither study found a significant difference in operative time with the implementation of microbreaks. Still, despite the relative wealth of data supporting their benefits, microbreaks are not a ubiquitous practice, which may be due to lack of awareness, lack of administrative commitment, and/or surgeons' resistance to changes in routine.[32] Furthermore, little is known about the proportion of surgeons performing such

Technology	Benefits	Cons	Photo
Inertial Measurement Units (IMUs)	Measures intraoperative muscle strain allowing for real-time intraoperative ergonomic optimization	Added bulkiness may limit use of other wearable technologies such as operative headlamps or exoskeletons, lack of widely available commercial systems	1 
Anti-fatigue mats	Reduces foot pain, improves surgeon comfort	Difficult to reposition, added cost, perceived comfort is surgeon-dependent	
Exoskeleton	Reduces extremity and lower back fatigue during prolonged static positioning	Financial investment, sterility and maintenance concerns	2 
Operative exoscope	Reduces ergonomically unfavorable neck and upper extremity position compared to traditional operative microscope, heads-up display offers ease of intraoperative teaching, may reduce operative time	Financial investment, may have associated learning curve	3 
Single-use digital flexible ureteroscopes	Lighter weight reduces wrist and arm pain associated with flexible ureteroscopy, high-definition digital camera improves visualization	More waste-generating compared to reusable scopes, may be more expensive depending on case volume	
Robotic ureteroscopy	Reduces wrist and arm pain associated with flexible ureteroscopy, seated surgery improves lower back and leg pain, improves visualization	Expensive, bulky, some systems are incompatible with existing ureteroscopes, may have associated learning curve	4  Above: Roboflex Avicenna Below: ILY Robotic Ureteroscopy System

Figure 2. Existing technologies for optimizing intraoperative ergonomics in urologic surgery. (Color version available online.) Selected images reproduced with permission from: 1, 2, 3, 4. (1) Gonzalez D, Ory J, Nassau D, et al. PD58-05 measuring ergonomic risk in operating surgeon by using wearable technology: a comparison of a 4k-3d exoscope to the operating microscope in male fertility microsurgery. J Urol 2021;206:e1018. (2) Exxovantage. Mid Height Exoskeletons. Accessed March 20, 2023. www.exxovantage.com. (3) Reddy R, Chu K, Deebel NA, et al. A comparative analysis of ergonomic risk utilizing the 4 K-3D exoscope versus standard operating microscope for male fertility microsurgery. Urology 2022. (4) Gauhar V, Traxer O, Cho S-Y, et al. Robotic retrograde intrarenal surgery: a journey from back to the future. J Clin Med 2022;11.

breaks across urology or other fields. One potential strategy which may increase the use of intraoperative microbreaks is performing an "ergonomic time-out" prior to or during surgery.[4]

Intraoperative Devices. In addition to changes in surgeon behavior, emerging technologies in surgical instruments, devices, and operating room equipment have shown ergonomic advantages (Fig. 2). Antifatigue mats are soft underfoot pads for surgeons to stand on in the operating room. These mats have been implemented in industries outside of medicine, and are recommended by the United States Department of Labor's Occupational Safety and Health Administration (OSHA) for workers who spend extended periods of time standing on hard surfaces.[33] Prospective data shows decreased foot pain and overall surgeon discomfort among urologists using antifatigue mats during laparoscopy compared to those who don't.[34] Similar findings have been seen in endourology, with prospective data showing significant improvements in postoperative discomfort and energy level following use of a gel pad.[35] Despite their advantages, antifatigue mats are not universally well-received – some surgeons have complained of difficulty positioning the mats, while others have reported a counterintuitive discomfort from standing on the mat instead of a hard floor.[36]

Another intraoperative intervention which has been proposed for reducing musculoskeletal injury is the exoskeleton. Exoskeletons are external devices that offer passive support to the wearer, thereby reducing active effort and musculoskeletal fatigue. These devices can be donned prior to scrubbing and worn underneath a surgical gown to allow for prolonged static positioning of extremities during surgery. A study utilizing EMG showed significant reduction in biomechanical demand of truncal musculature while using an upper body exoskeleton, allowing for users to sustain awkward postures with higher degrees of trunk flexion during surgical simulation.[37] Intraoperative use of exoskeletons has been shown to offer ergonomic benefit, with 85% of surgeons reporting significant reductions in postoperative shoulder pain after using an upper body exoskeleton.[38] Still, though this technology has demonstrable benefit with supportive data, its real-world implementation has been sluggish. Multiple barriers have been identified which may contribute to the lack of widespread adoption of exoskeletons in the operating room, including lack of awareness, as well as concerns over safety, ease of use, sterility, financial investment, and maintenance.[32] Cost analyses, industry support, and trials are all lacking in this space.

Approach-specific Ergonomic Innovations

Open Surgery and Microsurgery. Within the past 15 years, a novel surgical loupe design has emerged which incorporates deflection lenses that provide improved ergonomics. These deflection lenses involve an angulated optic axis, allowing the surgeon's neck to remain upright and eyes to remain in a forward gaze.[19] By reducing the degree of neck flexion, deflection loupes have demonstrated reduced trapezius EMG activity and decreased surgeon-reported neck and shoulder pain.[19,39]

The standard operative microscope has been shown to promote uncomfortable positioning, particularly for the assistant surgeon.[40] An alternative to traditional microscopy is the exoscope – a high definition, high magnification, three-dimensional digital camera coupled with wearable glasses on the surgeon. Among urologists, use of exoscopes has shown reduced ergonomically-unfavorable neck and upper extremity positioning as well as reductions in surgeon-reported discomfort.[41] In addition to the ergonomic benefits, exoscopes are associated with shorter operative times and turnover times, as well as easier intraoperative teaching.[40] While promising, this technology is novel and has yet to be broadly implemented. Though the cost of exoscopes are not inherently higher than traditional operative microscopes, the purchase of an exoscope represents an additional cost for hospitals that already own the older technology.[42] There have also been concerns cited over the learning curve associated with exoscopes, as well as a more onerous method of repositioning compared to traditional operative microscopes.[42]

Endoscopic Surgery. Endourology, particularly flexible ureteroscopy, is known to carry a high risk of musculoskeletal injury owing to prolonged shoulder abduction coupled with excessive thumb flexion and wrist extension.[5] Endourologists are 1.7 times more likely to experience hand or wrist problems compared to other physicians.[43] In a global survey of more than 500 urologists, 81% reported musculoskeletal pain due to flexible ureteroscopy in the past 12 months.[15] Digital flexible ureteroscopes are a recent development which are lighter and easier to manipulate compared to traditional fiberoptic ureteroscopes, and obviate the use of heavy camera systems. While some of the older reusable flexible ureteroscopes require forces in excess of 40 Newtons to achieve maximum deflection, disposable digital flexible ureteroscopes have demonstrated lower forces required for deflection.[13] Ludwig et al employed wearable EMG devices to quantify ergonomics during flexible ureteroscopy, finding significantly decreased muscular workload and improved ergonomics with digital ureteroscopes compared to fiberoptic.[44] Another study by Wright et al demonstrated increased EMG activity in forearm extensor muscles among endourology fellows using reusable compared to disposable ureteroscopes.[45] These advantages should be balanced against the potentially higher costs and increased waste associated with disposable digital ureteroscopes. Formal cost-benefit analysis has suggested that disposable ureteroscopes may be more cost-effective for lower-volume centers, while higher-volume centers may financially benefit from reusable scopes.[46]

More recently, robotic flexible ureteroscopy has been proposed as an alternative to handheld ureteroscopy, aiming to improve ergonomics and visualization. Several devices have been developed, most of which involve a robotic arm docked at the bedside attached to a fixed ureteral access sheath. A flexible ureteroscope is advanced through the access sheath and attached to the robotic arm, while the surgeon controls movement at a separate, seated console. The Roboflex Avicenna (ELMED) has been in development since 2008, and has preliminary data demonstrating improved ergonomics when compared to traditional ureteroscopy.[47] Other similar devices compatible with on-market ureteroscopes include the EasyUretero (Roen Surgical) and the ILY robotic ureteroscope holder (STERLAB).[48] More recently, Auris Health has developed the Monarch system, which uses a proprietary robotic endoscope component rather than interfacing with on-market ureteroscopes, and was granted clearance by the Food and Drug Administration (FDA) for use in urology.[48] Evidence in this space is lacking – to date, a single prospective study has been done comparing outcomes between robotic and traditional flexible ureteroscopy, which suggests similar operative time and stone-free rates.[49] Overall, robotic ureteroscopy is in its infancy with limited data on efficacy compared to traditional ureteroscopy; concerns over acquisition costs and maintenance costs have prevented widespread use of this novel technology.

Robotic Surgery. With two decades having passed since the development of the da Vinci robotic system, many of the patents within Intuitive Surgical's portfolio are now expiring, opening the market to competitors developing new robotic surgical systems.[50] Examples of these novel robotic systems include Hugo (Medtronic), Versius (CMR Surgical), Senhance (Asensus Surgical), Avatera (Avateramedical), hinotori (Medicaroid), and Ottava (Johnson & Johnson).[50,51] Many of these systems have novel features which may prove to confer ergonomic advantages, such as the pistol-like control grip of the Hugo system, an option to operate while standing, and open-console designs with three-dimensional glasses, enabling heads-up operating with free range of cervical motion.[51] As most of these devices are uncommon and/or relatively new-to-market, research surrounding ergonomic characteristics of these systems is lacking and represents a promising area of future study.

Ergonomics Education

One particularly concerning trend is the ergonomic burden placed on surgical trainees. Nearly 90% of surgical residents and 75% of medical students report musculoskeletal symptoms during surgical training.[6,52] This is especially problematic, as trainees may not have knowledge of best practices or access to technologies that can mitigate or prevent ergonomic injuries. This ergonomic burden is exacerbated by a lack of ergonomics education across surgical specialties. Over 75% of surgeons and 80% of urologists have received no prior training in ergonomics.[53] In one recent global survey, only 16% of urologists reported receiving formal ergonomics training.[15]

Despite prospective data demonstrating decreased pain and increased perceived overall health among surgeons who undergo formal ergonomics training, no widespread formalized curriculum for ergonomic education has been proposed for urology residents.[54] Several general surgery residency programs have formalized curricula which can provide a framework for implementing an ergonomics curriculum into current urologic educational models.[6] A peer-based curriculum was recently developed by Duke University Department of Surgery in collaboration with Duke Ergonomics Division.[55] Chief surgical residents were first trained as surgical coaches, who then trained junior residents on proper surgical posture through observership and ergonomics laboratories. Chief residents also train the rising chiefs, who then become ergonomic coaches. This collaborative teaching model can be easily integrated into the educational program at most urology residency programs. An alternate model developed at the University of Miami centers around a series of modules teaching surgical ergonomic principles, microbreaks, and exercises, and has shown promising results, with 85% of trainees reporting decreased pain after attending these sessions.[56] While the logistics and initial time investment may be challenging, the overall contribution to educating the future workforce may bolster longevity and improve rates of burnout.

Urologic Ergonomics and Equity

As the urologic workforce expands, efforts toward inclusion and diversity must also include efforts to promote career longevity. Currently, roughly 10% of the urologic workforce is comprised of women, and with 35% of urology residency positions matched by women in 2022, this proportion is expected to rise over the next decade.[57] Women as laparoscopic surgeons are more likely to have increased muscular activation, have worse physical discomfort, and require treatment compared to male laparoscopic surgeons.[58] Among urologists, there are higher reported rates of work-related physical discomfort among female physicians compared to males, which has

Table 1. Opportunities and actionable unmet needs in urologic ergonomics.

Ergonomic Component	Unmet Needs
Ergonomics training	• Incorporation into residency curriculum • Widespread formal faculty training • Ergonomics coaching programs
Technology, equipment, and devices	• Industry support, device representation at conferences, physician, and hospital adoption • Cost-benefit analyses • Prospective randomized trials
Ergonomics advocacy and research	• Prioritization by professional societies • Establishing surgical ergonomic guidelines • Funding for research • Determining the cost burden for lost work • Efforts to improve equity and inclusion

been suggested to cause increased risk of burnout for women urologists.[57] Multiple factors have further exacerbated this issue, including how instruments are trialed and the national regulations that scrutinize these instruments. Surgical instruments are often designed and tested using larger, typically male, hands, which creates inconsistencies in creating a universally ergonomically sound instrument.[59] Such disparities exist even in robotic surgery; despite the da Vinci console's built-in adjustable ergonomics feature, some shorter-statured surgeons may have difficulty using the eyepiece or reaching foot pedals in an ergonomically-favorable manner.[17] Once surgical instruments have been introduced in the market, any modification in device design requires additional premarket notifications for biotechnology companies. This environment disincentivizes surgical ergonomic innovation and makes technology less adaptive to a changing workforce. With demographic shifts in the workforce this may become more burdensome.

Future Directions and Unmet Needs

Despite the recent rise in notoriety of ergonomics in urology, key knowledge gaps exist that represent areas ripe for future research (Table 1). Further ergonomic research is still needed within the field of urology, in both operative and outpatient environments. Specifically, studies using objective measures such as EMG or IMUs are needed, and prospective randomized trials are lacking. While there are products available on the market which can quantify and even improve ergonomics, formal cost-benefit analyses are rare and should be performed to better assist physician and institutional decision-making. As new products come to market, their ergonomic attributes should be studied and reported. As mentioned previously, incorporating ergonomic material into urologic training programs, faculty and operating room staff training, and surgical coaching programs represents a necessary step toward disseminating these topics and educating the urologic workforce. The American Urological Association (AUA) and the Accreditation Council for Graduate Medical Education (ACGME) have an opportunity to emphasize ergonomics in residency training and consider expanding funding and facilitating research endeavors that target urology-specific ergonomic needs. The American College of Surgeons has established a Surgical Ergonomics Committee which recently published formal Surgical Ergonomics Recommendations.[18] While the AUA has published a quality-improvement document on optimizing outcomes in urologic surgery which includes a section focused on improving surgical ergonomics, there are currently no formal guidelines or best-practice statements surrounding ergonomics in urology.[60]

CONCLUSION

Maintenance of good ergonomic principles is central to improving intraoperative performance and maximizing surgeon longevity. Ergonomics in urology have been understudied until recent years, and even as more interventions emerge, key knowledge and access gaps exist that warrant attention. Multiple technologies exist today with proven ergonomic benefit, however, there is a dearth of ergonomic devices which are specific to urology, and cost analyses are needed to demonstrate feasibility for practicing urologists. If these technologies are found to be affordable and beneficial, guidelines on their use can be implemented to increase awareness. There are likely a preventable number of urologic work-related musculoskeletal disorders, particularly among trainees and women – making changes to prevent these is vital to preserving career longevity and promoting diversity, equity, and inclusion within urology as a field.

Declaration of Competing Interest

The authors have no competing interests or conflicts of interest to disclose.

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