BJS Academy

Surgical ergonomics: how and where to start?

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The field of ergonomics is dedicated to understanding the interactions between humans and elements of a system, with one of the core tenets of ergonomic approaches being the need to fit the environment to workers. It includes physical, cognitive, and organizational ergonomics that are all needed to create safe and efficient work environment (**Figure 1**). In the fast paced and high-stakes operating room (OR) environment, this principle is often forgotten. Surgeons, anaesthetists, and nurses alike tend to adapt their cognitive and physical work to a sometimes hostile work environment. Poor ergonomics in the OR can lead to musculoskeletal disorders, absenteeism, modification in clinical practice, reduced career longevity, and burn out, in addition to downstream repercussions on the risk of intra-operative complications, patient safety, and sustainability of the healthcare workforce (**Figure 2**).[1–4] One of the main protective factors against poor ergonomics is awareness of optimal practices.[5] This review will present key principles for optimal ergonomics in the OR.

Personal equipment

This aspect is one that can be more easily controlled by individuals in the OR.

- **Shoes**: Well adapted footwear can prevent complaints related to lower extremity discomfort from prolonged standing, such as sore feet, lower limb oedema, muscle fatigue and low back pain. Shoes should allow for toe freedom, arch support, and have a 1-2.5cm heel (flat shoes increase strain on the Achilles tendon).[6]
- **Stockings**: Knee-high compression stockings of 15-20 mmHg are suggested to reduce lower extremity muscle pain, fatigue, and oedema.
- **Loupes**: Because forward head posture increases loading on the cervical spine by up to 20 kg, it is crucial to wear well-fitted loupes if they are needed. Neck flexion with loupes should not exceed 25 degrees to prevent spine and neck strain. Good posture without extensive flexion of the lower and especially cervical spine is important in decreasing musculoskeletal injuries (**Figure 3**). Consider trying high declination loupes or exoscopes.
- **Led aprons**: Wearing a lead apron increases body temperature by up to 1˚C, impacts on body mechanics, and adds strain to trapezoid and temporalis muscles and the lumbar spine.[7] Wearing a well-fitted apron including a vest and kilt/skirt is recommended over a single apron. In addition, weight-reliever aprons and back-aids such as exoskeletons exist, if needed[8]

OR equipment

Several components of the OR equipment can affect ergonomics. These may need to be addressed by discussions with OR leadership and the multidisciplinary team.

- **Room organization and set-up**: Clutter should be avoided in the OR. This includes removing any equipment that is not being used. Attention should be given to planning "equipment-free zones" for OR staff to circulate safely and creating non-cluttered space at the head of the bed for the anaesthesiology team. In addition, any wires along the floor should be taped down to prevent tripping. Finally, before starting an operation, it is suggested to check with the interdisciplinary team that all have access to a safe space to perform their tasks.
- **OR table**: Proper OR tables that allow movement to facilitate appropriate posture for all members of the team are crucial. For instance, the ability to lower the table or allow safe Trendelenburg position is key for optimal positioning (see Table height below).
- **Monitor placement**: For video-assisted surgery, such as laparoscopy or thoracoscopy, the monitor should sit 30-40˚ below the surgeon's eye level and directly facing the surgeon's body. To achieve this, the top of the monitor should be placed roughly at the surgeon's eye height, which will provide a slight downward angle for the eyes. This means that video equipment should be mobile in the room. Surgeons may want to consider positioning the monitor themselves before scrubbing.
- **Anti-fatigue mats** (**Figure 4**): The Occupational Safety and Health Administration (OSHA) recommends the use of anti-fatigue mats for employees who need to work in uncomfortable positions for prolonged periods. This includes workers in the OR. Therefore, while surgery studies have not been conclusive on this topic, largely owing to limited design and sample size, anti-fatigue mats are suggested for long operations. These mats can be cleaned as directed by hospital Infection Control regulations and be used either on the floor or on step stools.

Posture in the OR (Figure 5**)**

- **Optimal posture**: Optimal posture involves standing straight, with the head over the shoulders, the shoulders over the pelvis, feet at hip width apart, and weight distributed on both feet.
- **Table height:** The OR table should be set to allow for elbow flexion between 90-120˚. If the table cannot be lowered sufficiently, step stools can be used. It is recommended to set the table height for the tallest person on the team, with others using step stools, if necessary. Patient positioning is also crucial to create space for movement around the OR table. For example, avoiding the use of arm boards and tucking the arms in creates space along the side of table.
- **Hand positioning:** To avoid extreme range of motion and avoid strain and injuries, surgeons can think about working with their hands and forearms "within a box". This includes maintaining elbows bent at 90˚, not crossing the midline with hands, and avoiding twisting.

Ideal positioning may not always be possible depending on the demands of surgery. Surgeons, anaesthetists, or nurses may need to bend or hunch over temporarily to perform specific tasks during surgery. The most important thing is to avoid these at-risk positions for prolonged periods. Thinking about a posture reset every so often during surgery can help. When thinking of posture reset, take the time to resume the ideal posture before continuing with surgery. When doing so, one may also invite colleagues to do the same.

Stretching for the OR

Stretching between and during OR procedures can reduce pain and strain for OR teams.

- Intra-operative stretch: Intra-operative micro-breaks of 60 seconds with stretching can be done without breaking scrub, standing or sitting (**Figure 6**). The programme developed by the Mayo Clinic has been shown to reduce pain significantly, without prolonging OR time, in a randomized controlled trial.[9,10] A web-app at *orstretch.mayoclinic.org* can be used. It includes a timer for micro-breaks every 45 or 60 minutes with a video link to guide teams through the 1-min stretches **(Figure 7)**. The Society of Surgical Ergonomics has also developed a toolkit for those who would like to implement the intra-operative stretch in their hospitals (https://www.societyofsurgicalergonomics.org/ergotools).
- Between OR stretch: Additional stretches can take place between procedures. The Mayo Clinic has developed a set of stretches that can easily be done in any space, such as the OR lounge (https://www.youtube.com/watch?v=bLAeVbBjZV0; https://mcforms.mayo.edu/mc7000-mc7099/mc7088-34.pdf).

Cognitive ergonomics

ORs are a very complex environment that involve more than physical demand. Cognitive ergonomics are concerned with mental processes, such as perception, memory, reasoning, and response, that affect interactions among humans as well as their environment. The system they all work within, including surgical culture, impacts on OR staff wellbeing. Following a systems approach is crucial when addressing workflow, flow disruptions, and stress that can lead to errors or injuries in the OR. Optimal ergonomics in the OR should involve physical, cognitive, and work organization.

What can you change?

Optimizing ergonomics in the OR is a long and complex process. It is not possible to change everything at once, or to aim for perfection immediately or all the time. We suggest starting with things that can be controlled within the immediate environment and building up towards other interventions involving OR teams and organizational changes as possible.

- **Things you can do tomorrow**:
  - Talk openly about ergonomics issues and challenges and discuss them with the multidisciplinary OR team including trainees, anaesthetists, and nurses.
  - Start using OR-Stretch™ for intra-operative microbreaks and take the time to stretch between operations.
  - Adapt your personal equipment: wear comfortable shoes with a small heel, compression stockings, and look at whether your loupes are well-fitted.
  - Think about a “posture rest” during operations.
  - Before starting surgery, check that the space is safe for all to do their work.
  - During surgery, look at the posture and comfort of the team: make sure the table height is set for the tallest person and others have step stools, and look at positioning of monitors when appropriate. Reset whenever necessary.
- **Things you can tackle after tomorrow**:
  - Get a personal consultation with an occupational/physical therapist or ergonomist to review your individual ergonomic concerns and possible interventions (including prevention!).

- Adapt OR equipment: use anti-fatigue mats, ensure OR table can lower and be used safely for extreme patient positioning.
- Plan OR set-ups: have floor plans laid out for frequent procedures to optimize space use and avoid clutter.
- Implement a team ergonomic time-out, which can be done after the safety checklist, to ensure safety of the OR team. A standard tool is currently being developed by the Society of Surgical Ergonomics; it can include checking on the table height, monitors position, arm tucking to create space, use of anti-fatigue mats, set up of the OR stretch app, and control of noise and temperature for example.
- Implement ergonomics education curricula for trainees and faculty.

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FIGURES

Figure 1. Three dimensions of ergonomics.

Figure 2. Reported repercussions of poor ergonomics in the operating room on surgeons. *Sources: Stucky CC et al. Ann Med Surg. 2018 Jan 9;27:1-8.*

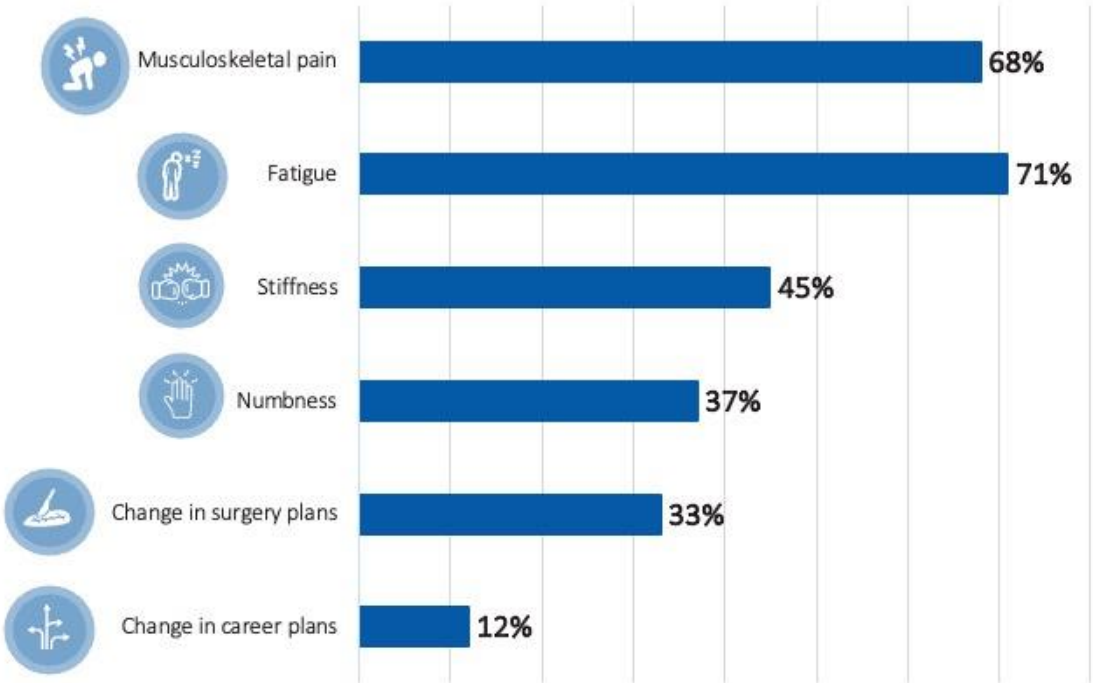

Figure 3. Optimizing posture to decrease extensive flexion of the spine includes wearing well-fitted loupes. Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.

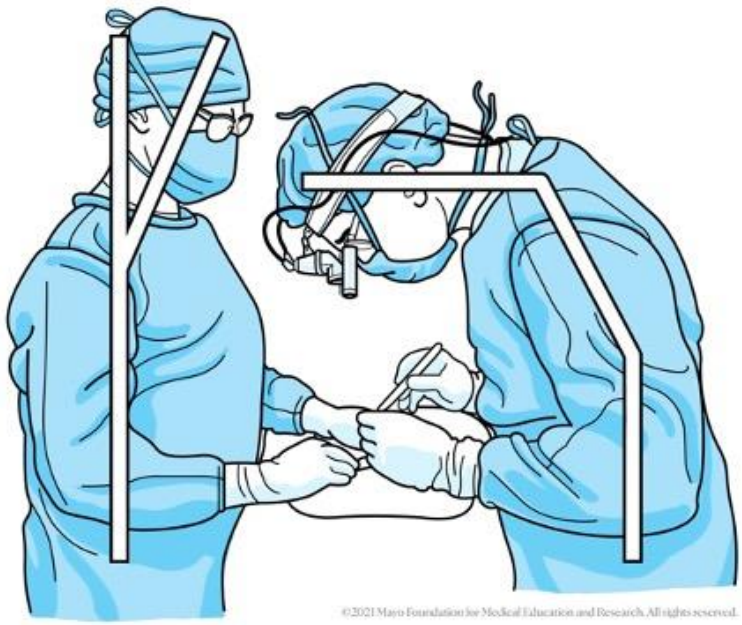

Figure 4. Use of anti-fatigue to prevent lower extremity and lower back strain, for floor (A) and step stools (B-C).

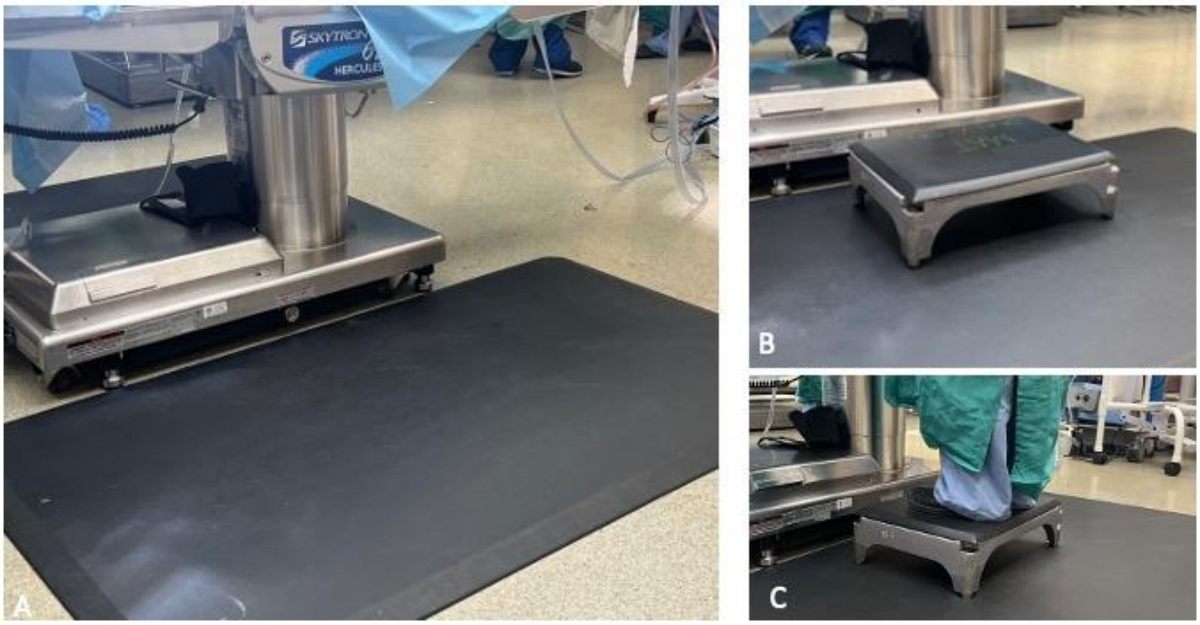

Figure 5. At-risk (right) and recommended (left) posture during open (A), laparoscopic (B), and robotic (C) surgery.
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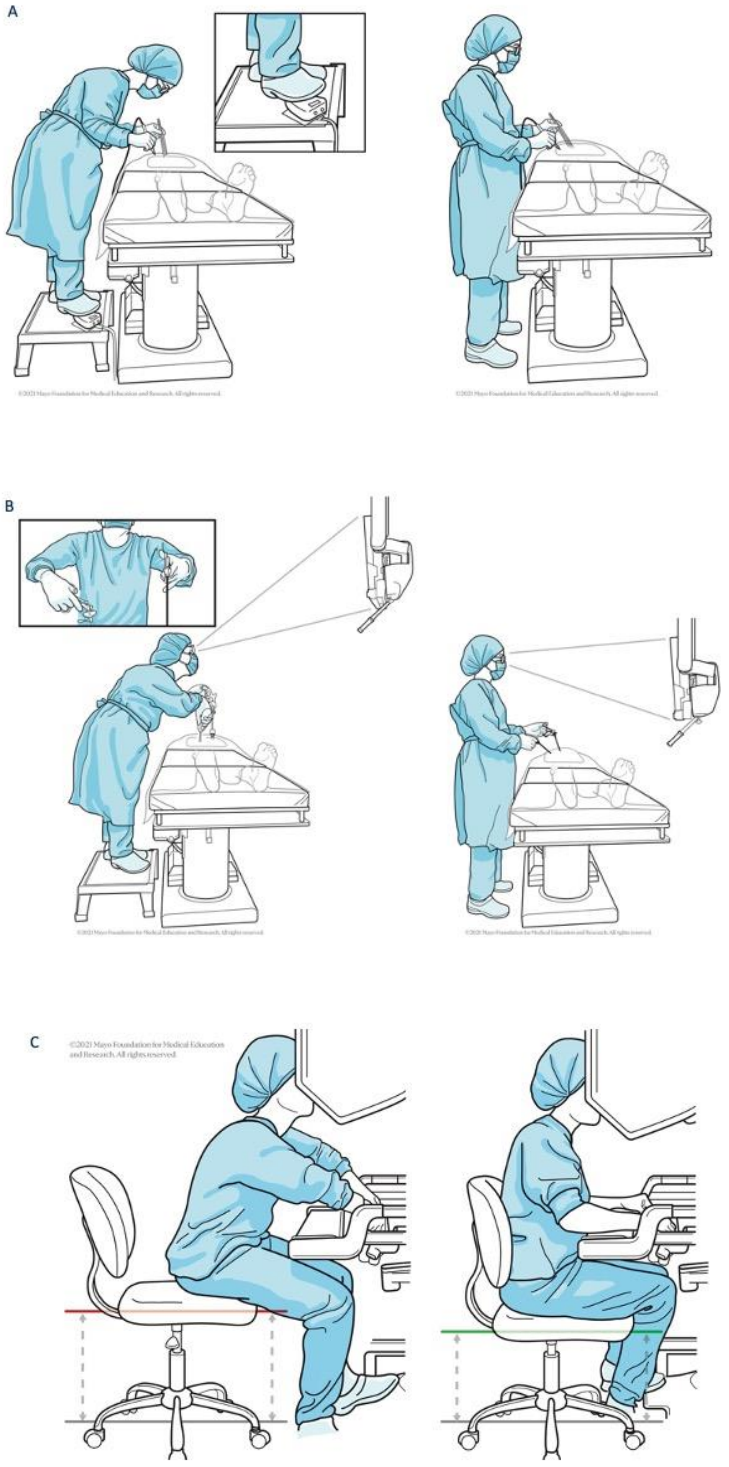

Figure 6. Stretch for intra-operative micro-breaks, standing (A) or sitting (B).
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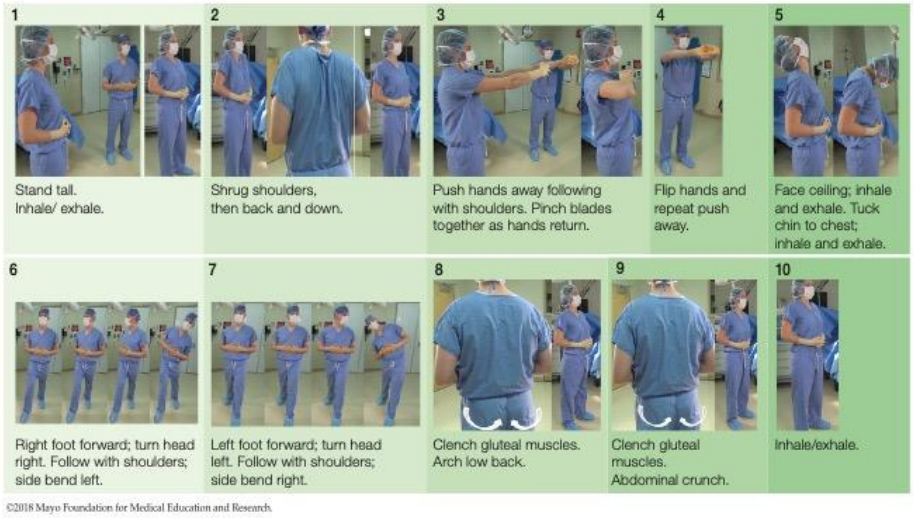
A



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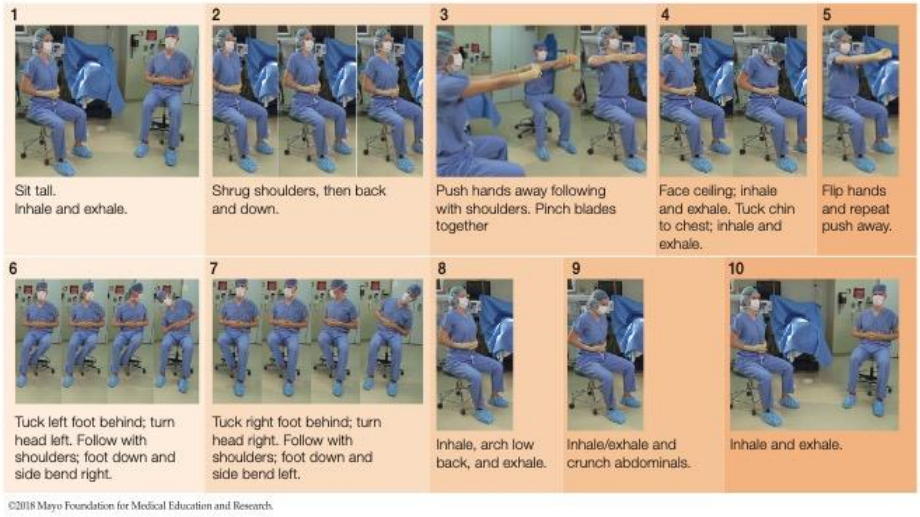

Figure 7. OR stretch web-application interface to support the implementation of intra-operative microbreaks (www.orstretchclinic.mayo.org)
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