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AIUM Practice Principles for Work-Related Musculoskeletal Disorder

The prevalence of Work-Related Musculoskeletal Disorders (WRMSDs) among ultrasound professionals has been significant. National and international efforts to create industry standards have focused primarily on injuries in sonographers. In addition, the Centers for Disease Control and Prevention (CDC) and National Institute for Occupational Safety & Health (NIOSH) have published documents related to this occupational exposure. There has also been significant attention on equipment utilization and design to help reduce the prevalence of WRMSDs. The American Institute of Ultrasound in Medicine (AIUM) developed the AIUM Practice Principles for Work-Related Musculoskeletal Disorder in collaboration with other organizations whose members use ultrasound [see Collaborating Societies and Representatives]. This document supports the "Industry Standards for the Prevention of Work-Related Musculoskeletal Disorders in Sonography" and aims to expand on these Standards to include safety practices for all health care professionals who utilize ultrasound. These professionals include members of the scientific community, a wide variety of medical professionals, and dental professionals. These ultrasound users and operators will collectively be referred to in this document as "operator(s)" except in those instances where data addressed those holding a specific job title, such as sonographer. In addition, this document will support guidance for quality improvement specific to preventing and reducing injury rates.

Key Words—Ergonomics; Occupational exposure; Work-related musculoskeletal disorders; WRMSD

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Abbreviations

BMI, body mass index; CDC, Centers for Disease Control and Prevention; CME, continuing medical education; MSK, musculoskeletal; NIOSH, National Institute for Occupational Safety & Health; PPE, personal protective equipment; QI, quality improvement; TTE, transthoracic echocardiography; US, ultrasound; WRMSDs, work-related musculoskeletal disorders

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Introduction

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The American Institute of Ultrasound in Medicine (AIUM) developed the AIUM Practice Principles for Work-Related Musculoskeletal Disorder in collaboration with other organizations whose members use ultrasound [see Collaborating Societies and Representatives]. This document supports the "Industry Standards for the Prevention of Work-Related Musculoskeletal Disorders in Sonography"[2] and aims to expand on these Standards to include safety practices for all health care professionals who utilize ultrasound. These professionals

include members of the scientific community, a wide variety of medical professionals, and dental professionals. These ultrasound users and operators will collectively be referred to in this document as "operator(s)" except in those instances where data addressed those holding a specific job title, such as sonographer. In addition, this document will support guidance for quality improvement (QI) specific to preventing and reducing injury rates.

Background

Work-related musculoskeletal disorders (WRMSDs) are painful injuries affecting the muscles, nerves, ligaments, and tendons of up to 90% of sonographers and other operators of diagnostic medical sonography.[3] Work-related musculoskeletal disorders result from the movements and maneuvers repeated multiple times a day by those performing ultrasound examinations, which may lead to serious health issues.[4] Moreover, of those sonographers who are injured, 20% will leave the profession due to their injury.[5] In addition to physical injury, WRMSDs result in both absenteeism and presenteeism (defined as continuing to work, despite pain, with a decrease in overall productivity), and these conditions take an emotional toll on operators and a financial toll (such as sick leave and workers' compensation) on employers.[5] Even given these numbers, some operators may be reticent to report their injury, for example, due to added workload on coworkers, lack of administrative support, or concerns regarding employer retaliation. A collaborative and engaging work environment allows stakeholders to identify risk, determine acceptable solutions, and implement corrective measures to reduce occupational hazards. Such an environment allows those experiencing work-related injury to express their concerns and facilitate appropriate reporting of injuries. Engaging all parties in establishing organizational practices and policies results in greater satisfaction and compliance.[6]

Among the many risk factors that can lead to the development of WRMSDs, some of the critical factors include the following:

- Poor ergonomics, including poor posture and machines with poor ergonomic design.[5]
  - Repeated use of equipment lacking ergonomic design.
  - Failure to apply ergonomic principles to scanning posture leading to muscle strain, discomfort, pain, and injury when poor posture and muscle overuse has been applied across multiple years. Unnatural postures and positions of the spine, unsupported reaching, and muscle overuse have specifically been identified as risk factors and are especially prevalent for ultrasound operators.[4]
- Poor workflow, including the positions of the machine, bed, and workstation.[5]
  - Improper equipment set-up and nonadjustable components lead to unnecessary arm abduction and overreaching that can diminish blood flow and cause muscle fatigue.[7]
- Lengthy exams with increasing workload and number of exams to be performed during the workday.[8]
  - Worldwide, the number of ultrasound examinations performed has exponentially increased, due to the fact that ultrasound is generally noninvasive and does not utilize radiation.[9] In Poland, for example, ultrasound examinations increased from 5 million annually in 2009 to over 15 million in 2015.[4]
- Inadequate breaks between examinations in addition to an increasing workload with less muscle recovery time.[7]
  - Microbreaks typically involve a pause in work tasks for as little as 30-seconds and up to 2–3 minutes every 20–30 minutes.[10,11] Studies have shown that micro-breaks, such as lifting the scanning hand off the patient and relaxing the hand while measuring an object, are essential with a varying workload to allow the muscles and joints to recover.[6,9] Microbreaks have been studied in other occupations that suffer with musculoskeletal disorders, including those who work for long periods at computer workstations, in surgeons, and those employed in the dental industry. Regularly scheduled microbreaks of 30 seconds duration have been shown to diminish discomfort without affecting productivity and can also improve mental focus.[12] In China, a survey reported that sonographers take a minimum break of 5 minutes per working hour to alleviate the risk of WRMSD.[9]
- Psychological stress and psychosocial factors in the workplace, increasing the risk for WRMSD.[13]
  - Increasing workload, poor control over schedule, and lack of management support lead to mental

burn-out, anxiety, and decreased job satisfaction.[13] Sonographers may scan in pain to meet the department's demands contributing to the development of WRMSD.[13]

- Unsupportive or inflexible environments that fail to account for the diverse abilities and experiences of individual operators, considering both work and nonwork factors, can impact operator health and well-being.[14]
  - A holistic approach to worker health and well-being considers not only the workplace's environment, safety climate, policies, and culture but should also support the various physical and mental health statuses, functional abilities, and lived experiences of workers.[14]

Work-related musculoskeletal injuries can result from a specific event (eg, tripping and falling), but WRMSDs among ultrasound operators are often the result of repetitive movements and static, sustained postures. For the ultrasound operator, the most common locations of WRMSDs include the shoulder, neck, wrist, and hands.[5] An individual's symptoms may vary, but some of the more common symptoms include aching, stiffness, sharp pain, weakness, tingling, and numbness.[5] These symptoms may be temporary and reduced with rest at the end of the workday,[5] or the symptoms may be more long-lasting, resulting in a long-term injury only obviated with medical and/or surgical intervention.

Education is crucial to prevent WRMSD, but current literature states the impact of this education is most significant in the short term, with continued periodic education needed.[8] In a study of Polish physicians performing ultrasound examinations, the vast majority of survey respondents stated that they "did not receive any education on the ergonomics and prophylaxis of musculoskeletal overuse, nor sought to educate themselves in this repose on their own (eg, by reading up on the subject)."[4] There is a paucity of training for physicians and point of care providers in ergonomics specific to sonography. Education on the prevention of WRMSDs is currently part of accredited sonographer education, however, the level of detail can be quite variable; and education should be continued throughout one's scanning career. Resources for education on WRMSDs are available in journals, textbooks, webinars, seminars, and conferences.

Some of the areas that can help to reduce or manage WRMSDs include allowing operators to sit or stand during procedures, having exam tables/beds that can be raised or lowered, and the ability to position the patient close to the operator to reduce stretching.[6] Additional resources for reducing and managing WRMSDs can be found in the following sections on Administrative and Personal controls.

Personal Controls

Symptoms of Work-Related Musculoskeletal Disorders

Pain is the most common symptom associated with WRMSDs.[3] Inflammation, swelling, numbness, muscle spasm, burning and/or tingling, and loss of sensation may also occur in the affected area. Some of these symptoms may cause loss of muscle strength, making it difficult to perform the daily duties of a sonographer/operator of ultrasound.

Work-related musculoskeletal disorders may progress from mild to severe, for example, from early to late stages. In the beginning phases of WRMSDs, the ultrasound user may experience aching and tiredness of the affected area. This is generally noticeable during the workday but subsides after scanning tasks are completed.

As WRMSD progresses, tiredness and aching occur earlier in the shift and continue past the work hours into time away from work. The repetitiveness of ultrasound exams becomes more of a challenge and the ultrasound user experiences noticeable effects outside of the workplace.

In the later stage of WRMSDs, weakness is added to the symptoms suffered and generally experienced throughout the workday. These persist continually outside of the office, affecting other aspects of life, including sleep and light activities.

The stages are variable in their appearance and progression from person to person. Not every injury occurs nor presents the same. The stages may tend to overlap, and the length of each stage is unpredictable due to variable factors. At the first onset of pain due to WRMSDs, rest and recovery should occur along with an evaluation of the

repetitive event and corrective actions to reduce the possibility of further injury. Injuries occur when pain is present and the causative factor continues to be repeated. The pathophysiology of many WRMSDs is complex and can simultaneously affect multiple parts of the body.

No singular etiology or event causes WRMSDs, but rather repetitive trauma over time and ignoring early warning signs of pain may lead to WRMSDs. A thorough evaluation with early intervention during the beginning stages can limit and possibly prevent disease and reduce impairment from occupational exposures. Consultation with a licensed healthcare practitioner is recommended in early stages of WRMSD, as well as before beginning a new exercise or diet regimen or other activities that address personal health needs.[15–17] The following is a list of tools to aid the individual in preventing WRMSDs:

Exercise

Focus attention on muscles used regularly while scanning.[18,19] There are a number of generally accepted exercise practices to improve overall health.

- Warm up and loosen muscles prior to starting the scheduled day.
- Perform a daily stretching routine to increase blood flow and flexibility. Additionally, targeted stretching in areas of high or sustained muscle use during a micro-break can reduce muscle tension and reduce development of musculoskeletal symptoms[20]; for ultrasound users, this most commonly includes the neck, shoulders, wrists, and hands
- Participate in a regular strength training program (bodyweight or dumbbell exercises).
- Achieve 30 minutes of increased cardiac activity at least 5 days/week.
- This can be done all at once or in small intervals throughout the day.

Mental Health

- Apply appropriate sleep hygiene practices to aid in improving overall health and wellness.

Sleep and Mental Recovery

- Maintain a sleep schedule and routine.[21]
- Create a relaxing place to sleep.
- Participate in calming activities prior to bedtime.
- Limit naps during the day.
- Avoid consuming too much food and drink prior to bedtime.
- Include physical activity throughout the day.
- Manage stress—try not to go to bed angry or stressed.

Administrative Controls

Workplace musculoskeletal disorders frequently lead to work absences,[22] in some instances accounting for a median of 8 missed workdays compared to a median of 6 missed workdays for other illnesses.[23] They account for 33% of work-related injuries,[22] resulting in 130 million visits for health care services on an annual basis.[24]

They are estimated to cost $45–$54 billion each year in terms of workers' compensation and loss of productivity.[24] The cost associated with one employee with a WRMSD is estimated to be $28,000–$33,000 in direct costs and an additional $31,000–$36,000 in indirect costs.[25] According to the OSHA calculator,[25] the employer will always cover the indirect costs, and the direct costs will depend on the employer's worker compensation policies. The research indicates that WRMSDs occur at rates as high as 90% among sonographers,[3] thus the estimated direct and indirect costs related to WRMSDs may be higher. Administrators should collaborate with sonographers in developing policies that support sonographer safety and implement WRMSD prevention protocols.[26]

Administrative controls that should be in place include policies regarding:

Scheduling

1. Improve the work schedule to reduce the need for overtime shift work. This is a contributor to fatigue and burnout, which can lead to WRMSDs.
2. Ensure that exams are scheduled to allow rotation of exam types and complexity throughout the day, where feasible, which provides rest for the different muscle groups by easing repetitive use.
3. Provide time for scheduled breaks to increase muscle recovery time during a shift.

Proper staffing levels

1. Staffing levels should be sufficient to optimize patient care and prevent work-related injury. In areas where chronic shortages exist, stakeholders can consider participating in clinical education of sonography students.
2. Policies that address lifting heavy patients and the availability of suitable equipment, if needed, can reduce staff injury.

Proper ergonomic equipment as well as adjustable equipment

1. The computer, keyboard, and mouse should be on a table with adjustable height.
2. Depending on the specific exam, a table should have automated height control, Trendelenburg positioning, adjustable stirrups, moveable footrest, and cutouts.
3. The scanning chair should be height adjustable, have a footrest, and promote a proper sitting posture.
4. Protective ergonomic equipment should include such items as supporting blocks for the arms, wedges to support the patient in various positions, and an elbow strap (cable brace) to support the weight of the transducer cord.[27]
5. The equipment should easily adjust to allow sitting and standing during an exam.[2]

Room designs that facilitate proper ergonomics, such as adequate space for patients and equipment.

1. Design rooms that are at least 150 ft^2 to accommodate ultrasound equipment, ancillary equipment, the patient, and the ability to maneuver around the room.[2]
2. Have dimmable lighting controls.
3. Ensure that commonly used items such as gel, cleaning supplies, a sink, and linens are within easy reach in the room.
4. Portable examinations pose a particular challenge in room design and should be discouraged as a standard way to provide inpatient sonography services.

Workplace Culture

A workplace culture should support wellness and have transparent policies regarding reporting and tracking of WRMSDs.

Evans et al, in a survey of 2963 sonographers, found that 43% (n = 1276) believed that their pain was occupationally related, with less than half of the respondents reporting their injury to their administrators.[3] The overall findings highlight that there is an opportunity for administrators to take an active role in WRMSD prevention by implementing a reporting system. Early detection of work-related pain allows for treatment and interventions to be applied to prevent a WRMSD. The Occupational Safety and Health Administration has placed the primary responsibility for protecting workers on the employer.[22,28] Policies should be communicated clearly, should include clear directions, and assign responsibilities to designated staff. Policies regarding ergonomics should include operator input. The Occupational Safety and Health Administration indicates that successful prevention is dependent on worker participation in the process, including identifying the workplace hazards and suggesting solutions. Successful prevention programs will include the following workplace policies:

1. Develop a system for reporting and tracking WRMSDs, including early detection.
2. Encourage reporting of WRMSDs, and develop a culture that does not punish operators for reporting or acquiring WRMSDs.
3. Provide annual education in proper ergonomics and WRMSD prevention, which may include competency evaluation. It should inform sonographers of their risks, the benefits of proper ergonomics, and allow them to understand the importance of recognizing and reporting the early symptoms of a WRMSD.
4. Provide workplace programs that support sonographer mental and physical health.
5. Evaluate the effectiveness of the department's prevention program. Assessments should determine if goals are achieved and interventions are effective in preventing or reducing WRMSDs.

General Ergonomic Principles

Basic principles for ergonomics in sonography have been established through consensus conferences and

research focused on preventing WRMSD. These basic principles encompass the work environment, transducer positioning, and appropriate scheduling, including rest breaks.

The computer workspace and scanning workspace (the ultrasound machine, scanning table, and chair) are a mandatory prerequisite of proper ergonomics. The design of the environment is essential for moving the equipment—including the ultrasound machine, table, and chair—on suitable flooring, without space constraints, and with the ability to adjust the temperature and lighting to each operator.[13,16,29,30]

- Another basic principle is the need for adequate rest breaks. The majority of ultrasound examinations can be physically demanding on the operator and time-consuming by needing to capture numerous images for documentation while in awkward positions.
  - It is reported that regular breaks (>5 minutes) were associated with a reduction in WRMSD.[9,31] Therefore, ultrasound facilities need to factor in time for breaks to allow the muscles and tendons to recover.[9,13,29]
  - Micro-breaks are equally important during the working day, providing muscle-recovery time.[6,13,14,32,33] For example, taking the transducer off the patient and relaxing the hand while measuring a structure is enough to give joints a short rest.[9,13,34]
  - Scanning with the nondominant hand can also provide rest and recovery, assuming the stress of scanning with the nondominant hand does not contribute to musculoskeletal problems on that side.

Attention should be given to transducer handling (see Figure 1, A–E), focusing on using all fingers and the palm, a light grip, and minimal or no pressure applied.[13,32]

The wrist should be in a neutral position with limited flexion and extension during the scan.[7,13,30] Discomfort from the transducer design may cause hand and wrist disorders.[29,30]

Forceful gripping (see Figure 2, A–F) is associated with the onset of symptoms,[30] and long durations of pressure may substantially increase the risk of joint injuries, especially when scanning patients with an elevated body mass index (BMI).[30,35,36]

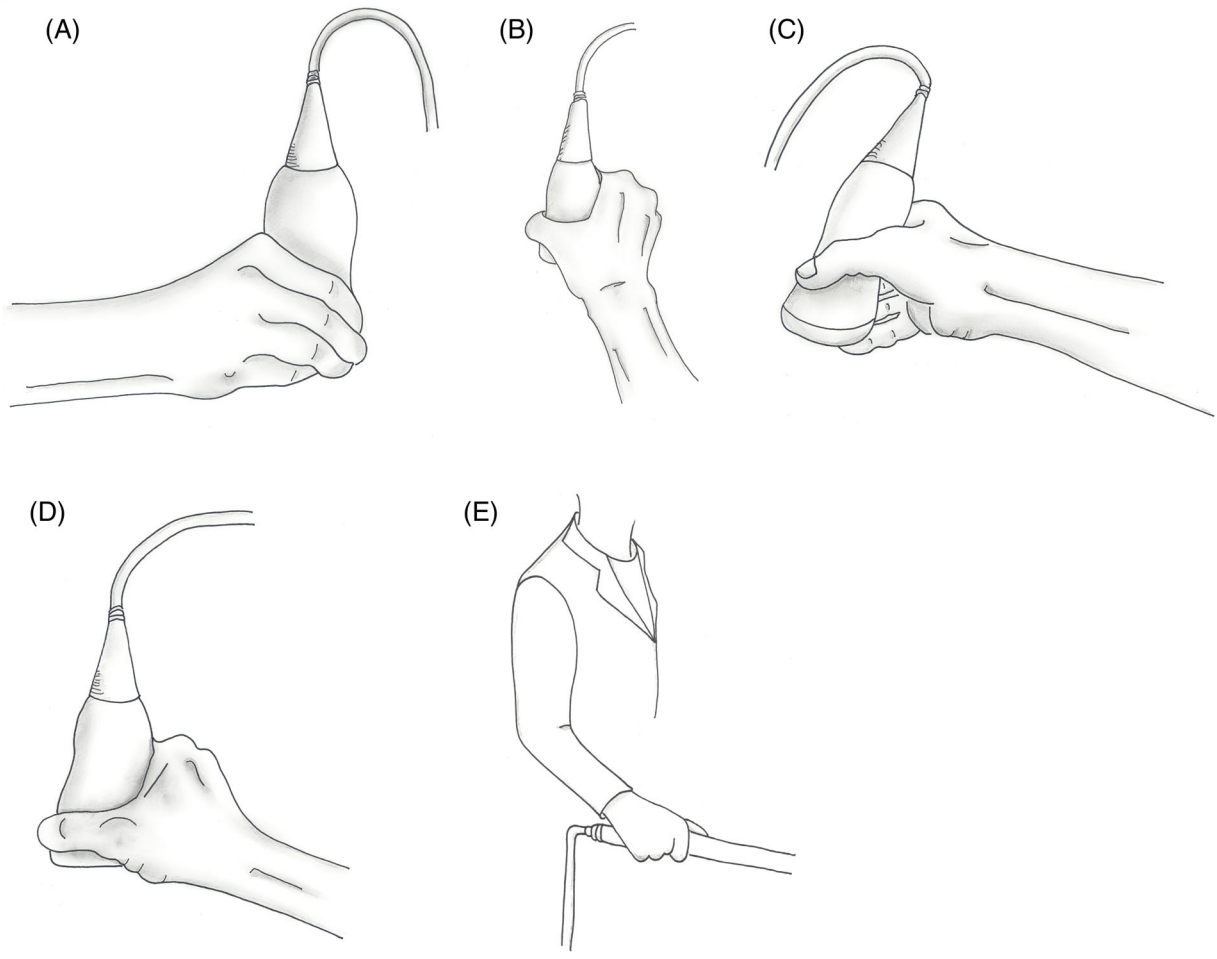
The operator should customize their ultrasound environment to promote proper ergonomic technique (see Figure 3, A and B). The following best practices can be used throughout the workday:

1. Proper positioning and adjustments should be accomplished at the beginning of each examination depending upon the body habitus of each patient.[30] Reaching movements should be avoided by keeping the operator, machine, bed, and patient as close together as possible and at appropriate heights by adjusting the examination table and chair.[29,30] It helps to have the patient slide close to the edge of the bed (see Figure 3A).
2. The operator's head and the screen/monitor should be on the same axis, and the eye-screen distance should be at least 60 cm. The top of the screen should be aligned with the level of the operator's eyes; then, the top of the screen should be tilted back slightly to encourage proper neck posture.[29,30]
3. The neck should be straight, and neck extension should be avoided.[13]
4. The operator should be positioned to allow the arm to be in a relaxed position with the upper arm close to the body (minimal flexion, ideally abduction <30°) and the elbow at a 90° angle, that is, the forearm should be horizontal to the floor allowing the shoulder to remain in a neutral position whenever possible,[13,29,30,34] using support cushions and bolsters when reaching is unavoidable.
5. A "wearable transducer cable support device,"[2] such as a cable brace, can be utilized to reduce arm strain during scanning. Also, the ultrasound transducer cable should not be passed around the neck as any traction force could result in a poor neck position.[29,30]
6. A scanning chair should be equipped with a backrest for lumbar support and adjustable height to mold the lumbar lordosis. Moreover, a seatback inclined between 10° and 20° is recommended. The back should be well supported on the seat. A slight gap should remain between the edge of the seat and the back of the knee, and the body should be on the axis of the screen. The chair should be height adjustable so the sonographer can be properly positioned relative to the patient and ultrasound system. Exam chairs should not have armrests as they may restrict access to the patient.

7. Exam tables should be height adjustable to encourage proper positioning by minimizing extended reaching, elevated arms, and wrist deviation, and allowing operators to stand and/or sit while performing procedures (see Figure 3B). Height adjustable tables also allow for sitting or standing and for a patient's safe access to and from the ultrasound examination table.[2]
8. The ultrasound machine keyboard should be easy to move and adjust.
9. Removing the transducer from the patient and relaxing the hand to allow for brief micro-breaks during the examination can help reduce muscle strain.
10. With the exception of point of care imaging, portable diagnostic exams should be limited to critically ill patients and those patients who are unable to come to the ultrasound department.[2]

In addition to the general ergonomic principles described above, specific types of ultrasound examinations bring unique challenges. Some of these challenges are addressed, by specialty, in the section below; however, this list does not include all specialty areas or examination types.

Figure 1. Appropriate transducer handling is as shown. **A**, The transducer in the longitudinal grip. The wrist is neutral. **B**, The transducer in the transverse position is deep in the palm. **C**, Deep palmar grip of the transducer. **D**, The hand positioned low on the transducer, gripped at the waist of the transducer. **E**, The shoulder, elbow, and hand correctly positioned for endocavitary imaging.

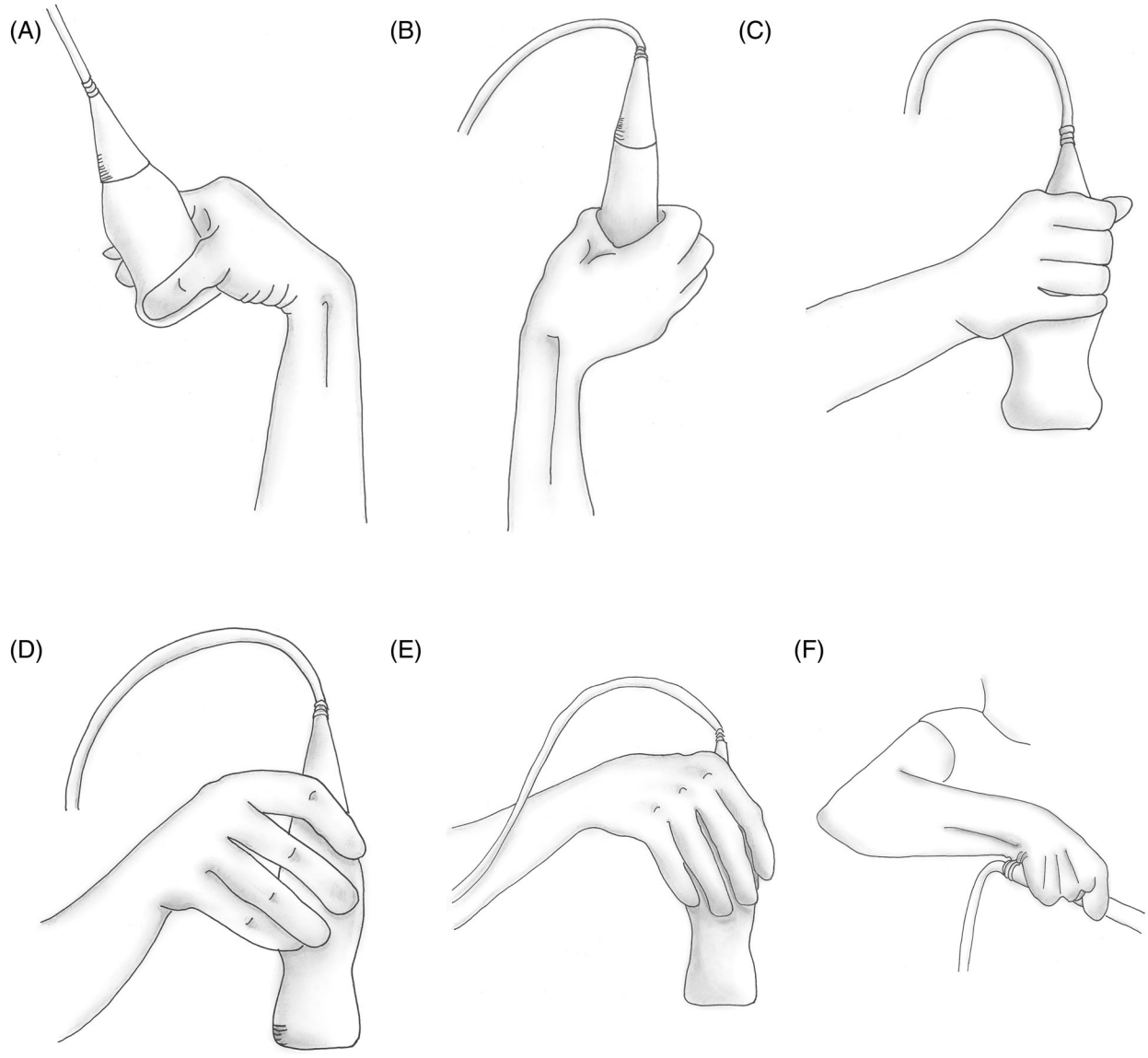


Consideration for Specialty Areas

General Abdominal/Small Parts

Abdominal imaging is most easily accomplished in an outpatient setting where ergonomic equipment, including ancillary equipment, is present. Challenges are more likely to be encountered in much less controlled settings such as acute care settings. When appropriate, applying the above recommendations for proper ergonomic applications may mitigate the challenges and barriers of bedside or point-of-care scanning.

Figure 2. Incorrect transducer handling. **A**, The wrist demonstrates too much flexion, which stresses the tendons in both the wrist and fingers. **B**, The wrist demonstrates too much extension, which stresses the tendons in both the wrist and fingers. **C**, The hand is too far up on the transducer with an excessive grip. **D**, The wrist is not in a neutral position and the fingers are too far from the base of the transducer, which does not allow for the arm to rest on the patient. **E**, The wrist is not in a neutral position and the fingers are too far from the base of the transducer, which does not allow for the arm to rest on the patient. **F**, The arm is stressed at the shoulder due to sustained elevation of the elbow, which does not allow for adequate support during an endovaginal examination.



One additional point for awareness in abdominal examinations is a risk associated with scanning patients with an elevated BMI.

- When scanning patients with an elevated BMI, varying the patient position such as a lateral decubitus position, may provide improved image resolution without excessive force.
- Heightening awareness of the amount of force used when scanning may provide the operator with important feedback information.
- Of interest, research has demonstrated that feedback information for the operator using a force measurement system can provide useful documentation of force used during specific examination types, various patient body types, and the length of time that force is applied. This may provide information to increase awareness and lead to a reduction in applied force and/or duration time with the goal of reducing musculoskeletal injury.[37]

Echocardiography

Several reports have demonstrated that some level of musculoskeletal pain occurs in over 85% of those performing echocardiography.[32,38,39] Adult transthoracic echocardiography (TTE) is physically demanding for the operator due to the long protocols and restricted transducer positioning.[40] Imaging from the apical window allows little room to maneuver the ultrasound transducer as it is wedged between the patient and the bed.

Newborns who are imaged in an incubator have limited access ports, requiring the operator to contort their body to reach both the infant and the ultrasound machine. These work-related ergonomic challenges are exacerbated in bedside imaging in critical care units and ultrasound departments that are not solely dedicated to scanning the heart. The extended examination time coupled with restricted transducer positioning often leads to poor ergonomics and hand posture, increasing the risk of developing WRMSD. Rearranging the room configuration can improve the ergonomic footprint in an effort to decrease WRMSD; however, efforts to reposition and reorganize equipment with associated time constraints can increase the risk of developing other musculoskeletal disorders.

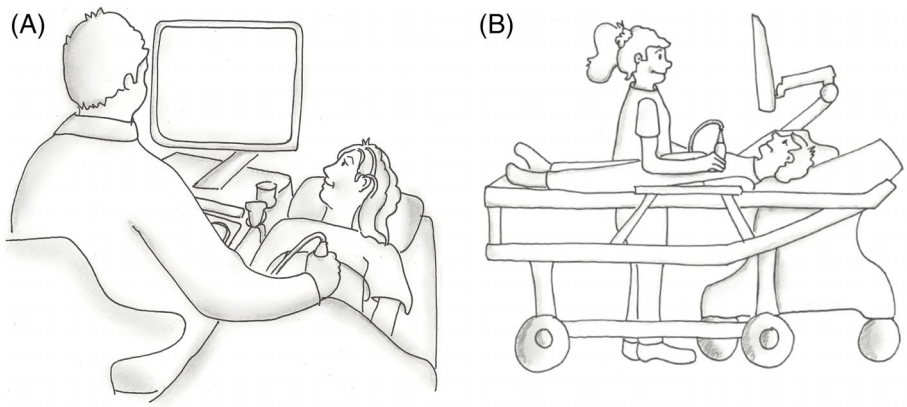
Risk Factors

- Scanning in locations with restricted space
  - Operating Room, Hybrid Operating Room, Heart Catheterization Lab, portable examinations
- Non-ultrasound equipment in the room preventing proper machine positioning
- Radiation exposure
  - Sonographers tend to stand on the unshielded side of the collimator.
  - The use of lead-lined personal protective equipment (PPE) introduces additional ergonomic risk factors.
- Limited patient access that results in awkward positions

Mitigation Strategies

- Utilize ultrasound bedding/tables that include drop-down sections for apical imaging.
- Limit portable exams to patients who are unable to be transported to the ultrasound department.

Figure 3. A and **B**, Customized ultrasound environments enabling proper ergonomic technique.



Gynecology

A survey conducted among practitioners of obstetric and gynecologic ultrasound found that 65.6% of them suffered from joint and/or back pain.[31] Some of the common reasons for these injuries are poor ergonomics, work schedules, and equipment design. The gynecologic ultrasound examination is usually composed of two parts—transabdominal and transvaginal evaluations—which lengthens the examination times. Operator schedules should be modified based on the number of scans, type of scan, and patient's body mass index. One risk factor identified for WRMSD is scanning more than 100 studies a month and spending longer than 25 minutes on an exam.[41] Any lengthy protocol, regardless of examination type, will increase the risk for WRMSD.

Transabdominal Pelvic Sonography

Risk Factors

- The grip on the transducer can be one of the reasons for WRMSD.[8,13]
- Heavier and larger transducers due to 3D and 4D technology can create additional strain.[41]

Mitigation Strategies

- Use a transabdominal transducer without 3D/4D technology for routine imaging.
- For patients with higher BMI, use a transducer with lower frequency, harmonics, or penetration settings.
  - An increase in BMI has correlated with an increased amount of pressure exerted by gynecologists or sonographers when performing ultrasound examinations.[42]
  - For patients with a pannus, have patient lift the pannus and scan underneath for closer access to pelvic anatomy. If the uterus is enlarged, scanning above the pannus may provide more optimal imaging windows.

Transvaginal Pelvic Sonography

Risk Factors

- A small study found that sonographers who performed transvaginal ultrasound examinations had an elevated Rapid Upper Limb Assessment score, which correlates strongly with an increased risk for a musculoskeletal disorder.[9,36]
- Endovaginal scanning requires more external rotation of the shoulder joint than transabdominal scanning.[41]

Mitigation Strategies

- Proper exam table that is height-adjustable, with moveable footrest and includes stirrups.
- Large enough room for the operator to move around freely and better aid patients with mobilization issues.[2]
- The ultrasound machine and control panel should be moved to the patient's feet, and the screen adjusted appropriately.
  - The table should be lowered or raised appropriately, depending on whether the examination is performed standing or sitting.
- Endovaginal scanning may be performed scanning between the legs or to the side of the patient.
  - Sit or stand between the legs of the patient. This is the most ergonomic position for endovaginal ultrasound examinations.
  - Alternatively, sit or stand close to the patient's right leg, reaching around, not over, the leg, which places the arm in a more restricted and awkward position. The operator should avoid excessive abduction of the shoulder.

Musculoskeletal Ultrasound

Ultrasound is a noninvasive imaging modality in the diagnosis of various chronic disorders, as well as acute injuries affecting the MSK system. Availability, ease of examination, and low cost of sonography make the initial evaluation and follow-up of healing lesions/injuries practical with ultrasound. Currently, there is an increase in injuries resulting in impairment and disability in ultrasound professionals performing MSK ultrasound imaging in the traditional office-based approach and the use of portable ultrasound at the bedside. Many injuries are directly related to poor ergonomics of exam tables, exam chairs, ultrasound equipment, and transducer design, size, and weight. Other injuries are due to the failure of the operator to adequately adjust the equipment environment to maximize ergonomic design and use. In addition, injuries are occurring more frequently due to an increased number of examinations with reduced time between examinations. These factors contribute to the increased rates of injury in this population of workers.

Mitigation Strategies

The ergonomic technique of MSK sonography of the ambulatory patient is as follows:

- Have staff assistance when positioning the patient.
- Place the joint of interest within proximity to the operator.
- Perform the exam sitting on an ergonomic stool or stand at an appropriate height so that the scanning arm is as close to the body as possible. Ensure the operator is not reaching, abducting the arm, or rotating to perform the examination. The most ergonomically sound position is the elbows flexed without extension or abduction of the shoulders.
- Ensure cervical spine and vision are in plane with the examination and the monitor is directly in front of the visual field of the ultrasound professional; shoulder examination may necessitate the patient to be placed on a rotary stool to allow the patient to be rotated anteriorly to posteriorly.
- Cable straps may allow less strain of shoulder and elbow joints.
- Choose the appropriate transducer for the specific examination based on the patient's body habitus.

The ergonomic technique of MSK sonography in the bedridden patient is as follows:

- Have staff assistance when positioning the patient.
- Slide the patient near the edge of the bed for the desired laterality of the examination, utilizing safe patient handling techniques, including Hoyer lifts. This allows the performance of the various dynamic movements necessary for the assessment of the shoulder or the joint in question.
- Place a rolled towel under the shoulder blade or lower extremity joint to allow posterior views of the rotator cuff or the lower extremity joint to be interrogated.
- Perform the exam sitting in an ergonomic chair or standing if the bed can be raised to an appropriate height.
- Place the monitor and equipment directly in front for viewing to avoid rotating the neck.
- Select required transducers for the examination based on patient body habitus. The majority of MSK examinations can be performed with 5–15 MHz linear array transducers. Patients with an elevated BMI require transducers with a frequency band of 3.5–10 MHz linear or a curvilinear transducer.

The ergonomic technique of MSK sonography in wheelchair-ridden patients is as follows:

- Remove the armrest of the wheelchair for the upper extremity to be examined to allow a range of motion assessment of various tendons and muscles of the upper extremity.
- Perform the exam sitting in an ergonomic chair or standing if the height is more appropriate.
- Place the monitor and equipment directly in front to avoid neck strain.
- For a lower extremity exam, place the patient on a stretcher or bed.

Obstetric Ultrasound

Work-related musculoskeletal disorder (WRMSD) among professionals practicing obstetric ultrasound (US) has been reported to be over 4-fold more common compared to other specialties and affects the upper limbs and the cervical and lumbar spine primarily. The transabdominal approach has been acknowledged as an additional risk factor for WRMSD compared to transvaginal US [see Transvaginal Pelvic Sonography risk factors].[30,43] Due to the known increase in WRMSD in obstetrics, special attention has been given to reiterating safety practices, especially those working in dedicated obstetric departments. This section discusses associate scheduling policies, the ergonomic aspects, and the strategies to prevent the occurrence of WRMSD when performing obstetric ultrasounds.

Mitigation Strategies

Monitor the number of hours and scans per day per person.

- Establish the number of patients per day, factoring in rest breaks;
- Establish baseline examination times in consultation with ultrasound operators performing obstetric examinations; and
- Avoid overtime and lengthy shift work.

Vary the types of scans.

- Schedule different types of exams for each operator to decrease repetitive movements and static postures attributed to scanning one type of examination.
- 3D/4D transducers are typically heavier than traditional low-frequency transducers. Use of a lighter transducer for exams and switching transducers as needed is encouraged.

Limit portable exams to cases that cannot be performed on patients in an ultrasound department or designated ultrasound room.[7]

Use WRMSD-prevention strategies when performing obstetric ultrasound in patients with an elevated BMI as well, as when performing transvaginal ultrasound. Scanning obese patients and transvaginal scans are among the types of examinations deemed more challenging in ergonomics.[9,13,35]

- Elevated BMI
  - An elevated BMI may require an extended reach and/or excessive arm abduction.
  - Patients with an elevated BMI may necessitate the ultrasound operators to exert more force.
  - Use equipment with good harmonics and appropriate presets to allow optimization.[34] Have low-frequency transducers available.
  - Lifting the pannus or scanning from above or to the side of the pannus can reduce the depth of tissue for sound to penetrate.[13,44] In addition, decubitus scanning, or a semi-prone/anterior oblique position with the upper leg flexed for stabilization, then scanning from the patient's flank, can improve image quality in such patients.[13,45]
- Endovaginal scanning may be performed by scanning between the legs or to the side of the patient.
  - Use a height-adjustable examination table with a moveable footrest and removable/collapsible stirrups.
  - Move the machine and control panel to the patient's feet, and shift the screen above the patient.
  - Sit or stand between the legs of the patient. This is the most ergonomic position for endovaginal ultrasound examinations.
  - Alternatively, sit or stand close to the patient's right leg, reaching around, not over, the leg. This does place the arm in a more restricted and awkward position. The operator should avoid excessive abduction of the shoulder.

Vascular Ultrasound Examinations

Vascular sonography is a medical specialty with prevalent WRMSD. Many operators stand on the right side of the supine patient when scanning and reach over the patient to scan the left side. This position places the operator's shoulder of the scanning hand in abduction, resulting in bending and twisting of the neck and trunk, often leading to an unbalanced stance through the lower extremities.[36] Time should be taken to consider the set-up of the room before placing the transducer on the patient. Emphasis is often placed on the scanning arm, but the non-scanning arm can also sustain injury from overextending to reach the equipment controls.[46]

The vascular ultrasound specialty comprises a variety of examinations, some of which may require special considerations when positioning patients to maintain safe scanning practices while attending to patient comfort and disease and mobility states. The following describes recommendations for the most common vascular examinations.

Mitigation Strategies

Carotid exam

- If the operator is sitting at the head of the bed, a support cushion should be used for the scanning arm.[45]
- If the operator is positioned at the patient's right side, the arm can be supported by resting on the patient's shoulder. When scanning from the left side, the patient is instructed to lie diagonally across the exam table. The patient's head will be closer to the operator.[47] The operator positions their arm with support across the patients' right shoulder, and the patient's legs are angled towards the opposite end of the table positioned towards the opposite corner.
  - Operators should be aware that patients with shoulder injuries, arthritis, and other joint diseases may not tolerate the weight of the scanning arm across the shoulder. A scanning bolster or cushion may also serve to support the arm.[45]

Lower extremity exam

- If the operator is scanning from the right side, the patient should be positioned closer to the right side of the bed, the ultrasound machine, and the operator. The ultrasound equipment should be positioned and moved appropriately so that the scanning arm is not reaching excessively forward or behind as the exam progresses down the leg.[47,48]
- If the operator is scanning the left leg, the procedure should be performed to avoid reaching across the

patient. This can be accomplished by having the patient reposition closer to the operator or with head down and left leg closest to the machine and the operator. Alternatively, the ultrasound equipment can be repositioned to the left side of the bed, and the operator scans the left leg with their left hand.[47,48]
- Rapid cuff inflators should be used when augmentation maneuvers are required.
- If the patient stands for the procedure, an elevated stair platform with hand railings protects the patient and enables the sonographer to maintain appropriate scan positioning. An exam table with a footboard will also improve patient safety and maintain proper sonographer ergonomics.

Upper extremity/Dialysis access exams

- Position the patient and ultrasound equipment close to the operator. The exam should be performed with the patient's arm closest to the operator to minimize reach. A bilateral exam requires repositioning of the patient and/or equipment.[47,48]

Abdominal/Mesenteric

- Patients should be positioned in the right or left decubitus positions to bring them closer to the operator and eliminate reaching as much as possible. Use of equipment harmonics or penetration presets may assist in the acquisition of diagnostic images in patients with elevated body mass index (BMI) to obviate excessive transducer pressure.

POCUS

Work-related musculoskeletal disorder (WRMSD) as a potential health problem when performing point-of-care ultrasound (POCUS) may not be acknowledged. During a typical shift, types of POCUS exams can vary widely and are shorter, often completed in fewer than 5 minutes. The number of studies performed is rarely more than 10 per shift, with downtime between scans. Despite these factors, POCUS operators are still at high risk for WRMSD.

Risk Factors

- All studies are portable, performed at the bedside where space is constrained and without proper ergonomic equipment.
- Machines and the operator interface may not be ergonomic. Some patients are immobile or uncooperative (eg, have a neurocognitive disorder, are intoxicated, critically ill, or intubated). Often, practitioners perform exams during emergent or challenging situations and under significant time constraints.
- Occasionally POCUS operators may need to scan in an awkward position or apply prolonged transducer pressure related to the patient condition and/or time-sensitive circumstances of the examination. The need to wear personal protective equipment and equipment covers may further add stress and strain on the operator.
- The use of handheld wireless devices adds an additional potential risk factor due to the weight and size of the transducers. Some manufacturers have suggested that removing the cable may help to mitigate some potential risk; however, the weight of the transducer in a palmar grip may induce injury. More research is required to elucidate both the protective measures and hazard-forming risks.

These unique challenges suggest that basic safe scanning techniques should be foundational in preventing WRMSD for point-of-care use.

Mitigation Strategies

- The patient, bed, and equipment should be appropriately positioned relative to the operator to reduce arm abduction, prevent overreaching, and limit awkward rotations of the neck, torso, hips, and back.
- Position the ultrasound machine and patient as close to the operator as possible to limit the scanning arm abduction to <30°.[49,50]
- The non-scanning arm should be comfortably resting on or near the machine, with the hand close to controls to reduce overextending.
- The screen height should be adjusted to keep neck flexion to ∼15°–20°[13] and positioned directly across the operator's view.
- The patient's bed should be high enough to avoid back flexion.
- The transducer should be held with a palmar grip to distribute pressure evenly across the whole hand[6,7,44] (Figure 1).

- Minimize wrist flexion and extension[44] and keep the forearm parallel to the bed (Figure 1).

Interventional Information

During ultrasound-guided interventions, many of the ergonomic techniques presented throughout this document apply in addition to these strategies.

Mitigation Strategies

- During interventional or intraoperative procedures, assistance may be provided for manipulating the transducer or interventional device/surgical device during the procedure.
- Additional personnel required may consist of an additional provider, sonographer, surgical assistant, or technician.
- Room design is critical to ensuring safety and efficacy to optimize patient outcomes. Sterile transducer covers add challenges to procedures, and maintaining sterility of the field requires added time for room adjustment to promote ergonomic design.

Quality Improvement

WRMSDs encompass painful injuries affecting muscles, nerves, ligaments, and tendons.[2] With the number and variety of examinations in different clinical scenarios, ultrasound operators are at increased risk for WRMSD.[36] The prevalence of WRMSD among the frontline sonographer workforce is steadily increasing.[2,51] Many, if not a majority of, ultrasound users report scanning in pain,[3] and a majority (up to 90%) of sonographers develop WRMSD gradually over time from repeated work stressors, poor positioning, and older injuries that have not been properly evaluated and treated.[2,3,36] As a result, sonography is recognized by the Department of Occupational Safety and Health Administration as a profession susceptible to musculoskeletal injury.[51,52]

If WRMSDs are overlooked and if workplace systems are not corrected, many sonographers may continue to scan in pain, worsening their injuries, reducing work hours, transitioning to other jobs, or leading to early retirement.[51] Protection of our frontline workforce is paramount in retaining individuals with valuable skills. This protection requires a change in industry mindset that acknowledges the shared responsibility among both employers and operators. A Consensus Conference on Work-Related Musculoskeletal Disorders was sponsored by the Society of Diagnostic Medical Sonography (SDMS) in 2016 as a system-wide effort to stimulate this change.[2,51] However, increased awareness of the magnitude of the problem and local QI efforts are necessary to ensure that these standards are translated into the successful reduction of WRMSDs among ultrasound operators.

An overview of the QI process for ultrasound operator safety and well-being is provided below to serve as a foundation for employers and operators to make meaningful changes within the local context.

Recommended QI Components for Operator Safety and Well-Being

QI programs start with a comprehensive *education plan*. Employers should provide education to new hires and offer ongoing opportunities for all operators.[2] Employers, hospital systems, sonography laboratories, and educational programs have a responsibility to educate their teams on best practices and train operators and their supervisors on methods to prevent WRMSD.[2] Education should review the personal control that individuals can undertake to support their own health, as well as incorporate hands-on training in appropriate ergonomic positioning for exams and exam rooms, including ergonomic adjustments/features of the sonography equipment. In addition to operators, education should be provided to administrators and managers regarding WRMSD among ultrasound operators, its magnitude and potential effects, and resources available at the site to implement controls to remediate the problem.

Employers should provide a culture of safety and well-being for their frontline workers. Practical aspects that may be considered in an organizational setting include incentives, stretching, strength building, educational in-services with a yearly compliance video, and built-in slots for breaks within the patient schedule.[51,52] Budgets should allow for up-to-date ergonomically designed equipment and other workplace accommodations to support safe operation and reduce the risk for injury or cumulative strain.[2] Operators should be encouraged to report early signs or symptoms of the development of WRMSDs (eg, recurring daily musculoskeletal discomfort, numbness in the hands) without concern for retribution or negative stigma when injuries

occur.[51] Incorporation of workplace changes to reduce employee injuries and avoid reinjury are needed, including resources to support proper employee positioning to maintain a neutral posture that decreases stress on the musculoskeletal system via operator education, equipment (eg, armbands, standing mats, ergonomic chairs), and administrative controls. Finally, ensuring that the workplace supports diverse functional abilities, cultures, and intersecting psychosocial aspects among all individual operators.[14] Employers who wish to create a comprehensive culture of safety and well-being may consider implementing a National Institute for Occupational Safety and Health (NIOSH) Total Worker Health program (U.S. Department of Health and Human Services).

On-going risk surveillance of workforce discomfort reports and operator injury, as well as methods for management of such injuries with a detailed assessment of change in the workplace or work to avoid reinjury, should be an integral part of the sonography laboratory or hospital system. Poor positioning, an increasing number of studies per operator, and the increasing number of portable studies, where proper positioning is often impossible, are major contributing factors to WRMSD.[36,51] As such, essential elements of QI risk surveillance include an assessment of workplace ergonomics, the number of scans and their difficulty per operator (see the Appendix for more information), the amount of break time between examinations, the number of portable scans, and the need to move equipment and patients.[51]

Quality Improvement Process

A QI program should include ongoing tracking or logging of ergonomic education for employees, safety and resource utilization, equipment updates, the numbers and types of reported symptoms and/or injuries, and organizational (ie, policies and practices) changes or updates made to improve employee safety and well-being. A review of these data, along with a status check on overall workplace culture and worker well-being, should be conducted annually. Employers might consider using a tool such as the NIOSH Worker Well-Being Questionnaire[53] (WellBQ) to assess the work place environment.

A QI team composed of individuals from all levels of the organization (eg, administration, management, staff) should review aggregated data from tracking logs and any annual work place environment reports to identify and prioritize areas for improvement. Depending on the size of the organization and available resources, 1–3 goals and actionable tasks should be developed to focus QI activities for the upcoming year. These ongoing reviews are vital to ensure that workplace safety programs rapidly adapt to reduce worker injuries.[33,54]

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APPENDIX

To avoid WRMSD, schedules should allow adequate time to complete all aspects of an examination including communicating with the patient, competently performing the examination protocol, and documenting preliminary findings. Such schedules should allow time for periodic breaks. Schedule planning should involve all members of the imaging team. Factors to be considered include the following:

- Type and complexity of the examination
- The patient's body mass index
- Employee training commitments—when scheduling examinations, employees need to be aware of any ultrasound trainee at the facility. Their stage in training is also important in order for the training to be effective.[34]
- Inpatient versus outpatient (patient mobility)
- Quality of the equipment
- Time for room preparation, cleaning of room and equipment, and specimen processing.
- The number of staff available to facilitate patient flow.[55]

The following is a list of *minimum* suggested times for complete protocols and are not meant to dictate examination times due to variability in the above-described circumstances nor are they meant for point-of-care indications. This is not an inclusive list of all ultrasound examinations that are performed. These times

Exam Type	Additional Time Allotment May Be Needed to Include Pre and Post-examination Preparations[a]
Abdomen: Complete	45 minutes
Abdomen: RUQ, Renal	30 minutes
Abdomen: Aorta, IVC (without Doppler)	35 minutes
Doppler: Mesenteric/Renal[b]	92 minutes
Doppler: Aorto-iliac/IVC-iliac[b]	71 minutes
Superficial Structures: Head/Neck, Thyroid	30 minutes
Men's Health: Scrotal, Prostate, Bladder	35 minutes
Obstetrics (singleton):	
Early first-trimester Routine	30 minutes
First-trimester Detailed	30 minutes
Second-trimester Routine	45 minutes
Second-trimester Detailed	60 minutes
Fetal Echo	50 minutes Additional scan time is required for each additional fetus
Women's Health:	
Non-gravid Pelvis	35 minutes (add 10 minutes if the additional exam is requested, eg, transabdominal/endovaginal)
Sonohysterography or hysterosonography (HyCoSy)	45 minutes
Endometriosis with evaluation for deep infiltrating endometriosis	45 minutes
Pelvic floor ultrasound	60 minutes
Unilateral Breast	35 minutes (add 10 minutes if the additional exam is requested, eg, additional views)
MSK: Complete joint (includes pediatric hip)	40 minutes (25 minutes if unilateral only)
Vascular:[b]	
Carotid unilateral/bilateral	46 minutes/67 minutes
Transcranial	73 minutes
Venous unilateral/bilateral	45 minutes/70 minutes
Arterial unilateral/bilateral	51 minutes/76 minutes
Cardiac[c]	45–60 minutes
Pediatric: Neonatal Head, Spine	35 minutes per examination

[a]Suggested examination times are based on the review of multiple professional documents and consensus of the AIUM Practice Principles for Work-Related Musculoskeletal Disorder Task Force.
[b]These recommendations were established by the SVU Vascular Technology Professional Performance Guidelines.
[c]These are standards from the Intersocietal Accreditation Commission.

mirror professional standards and guidelines, where applicable, or were derived by a consensus task force following a review of examination time guidance available in national and international documentation.[34,40,55–57]

Consideration for WRMSD Prevention Checklist

- Is a shared decision-making model used for scheduling patients?
- Does the length of examination times adequately consider patient needs and examination types?
- Are types of exams varied?
- Are the number of exams per day limited?
- Are portable exams limited to necessity and not based on convenience?
- Does the operator use healthy ergonomic practices when scanning?
- Does the schedule allow for adequate time for breaks?
- Can the machine, keyboard, and monitor be adjusted independently?
- Is the bed and chair/stool adjustable?
- Is lighting adjustable?
- Is annual continuing medical education (CME) in WRMSD required for the operator?
- Is there an injury reporting procedure published and available?
- Is the size of the examination room adequate to accommodate the machine, bed/stretcher, other equipment, or storage?
- Is a QI process in place that aims to monitor and reduce WRMSDs in ultrasound operators?