Recommendations for Sonographers to Work Safely, Comfortably and Healthfully

— Equipment and working environment to prevent work-related musculoskeletal disorders and eyestrain —

The Japan Society of Ultrasonics in Medicine
Ultrasound Equipment and Safety Committee

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1. Introduction

1.1 Necessity of efforts for injury prevention in sonographers

Ultrasonography is an essential examination used in many departments, and the importance of ultrasonography would not change in the future because of its high safety. Recently, not only many physicians conduct the examination but also sonographers often conduct ultrasonography continuously according to the centralization of examinations.

In Sonographers operate equipment with applying a probe held in a hand to various parts of examinee's body at various angles with gazing images at the same time. Therefore, when the examination is performed in an unnatural working posture, stress on sonographers' body becomes heavy as well as eyestrains because they need to carefully observe a display. Implementation of continuous examination associated with specialization of examinations could be a factor that increases the injury risks.

It has been clarified that ultrasonography has a risk of musculoskeletal disorders based on mainly research abroad[1) 2) 3)]. It is important that sonographers can work under conditions without injury risks to promote ultrasonography smoothly in the future; therefore, efforts on this issue are also becoming a challenge in Japan.

1.2 Actual situation in Japan

To resolve the above-mentioned problems, the Japan Society of Ultrasonics in Medicine established a Research and Development Team for "Ergonomics study on ultrasonic diagnostic equipment and examination environment for sonographers" under the Ultrasound Equipment and Safety Committee in fiscal year 2010 to examine countermeasures that enable sonographers to work safely, comfortably and healthfully.

The Research and Development Team conducted a research to clarify the current status of workload for sonographers in Japan and to develop preventive measures against musculoskeletal disorders. As the results, it was clarified that a number of sonographers conduct examination work with physically substantial burden in a busy schedule, and that a certain rate of sonographers have symptoms of musculoskeletal disorders and eyestrain, or anxiety about these disorders[4)].

According to 178 answers obtained from a questionnaire investigation targeted at facilities, 66% of facilities answered that some staff members engaging in ultrasonography complain of symptoms of musculoskeletal disorders. According to the results of a questionnaire investigation targeted at sonographers, in 463 answers, about 1 out of 4 sonographers have symptoms of musculoskeletal disorders, and have subjective symptoms including a sense of discomfort and injury of the right shoulder, arm and lower back, and eyestrains as popular complaint. In addition, it was clarified that a rate of sonographers who know that examination work has a risk of musculoskeletal disorders was only 40%, and almost no systematic countermeasures are implemented in medical facilities.

The Research and Development Team implemented an observational investigation in job site of

examination tasks in cooperation with medical facilities. As the results, several postures that have been known to become a risk of musculoskeletal disorders were observed. Especially, elevation of the arm holding a probe in examinations of the abdomen, heart, breast gland, and neck, and an inclination and twist of the upper body in examinations of the heart and abdomen, and unstable sitting positions are the most frequently-occurred high-risk postures[5)].. Also, vessel examination that applies a probe to a lower limb of examinees in a sitting position or standing position is associated with straining postures, such as substantially forward-bent or crouching postures. In addition, probes need to be applied at various angles against the body of examinees, and they need to be pressed down in some cases. In such cases, examination often conducted in a state that the wrist is substantially bent or that a probe is held in a manner that is hard to apply strength.

1.3 Purpose of the recommendations

These recommendations aim to provide necessary conditions required for sonographers to conduct ultrasonography tasks in safe and comfortable environment without risks of musculoskeletal disorders and eyestrain to promote good efficient ultrasonography, and then to maintain and expand opportunities for examinees to receive examinations.

1.4 Outline of the recommendations

To achieve the above purpose, these recommendations make a proposal for interested parties, sonographers, managers of facilities who have the stance to supervise and direct the sonographers, and manufacturers that provide equipment. The outline of the recommendations is as below.

(1) Recommendations for sonographers

For sonographers, these recommendations facilitate understanding about risks of musculoskeletal disorders and eyestrain, and indicate countermeasures that can be conducted by sonographers themselves.

(2) Recommendations for managers of facilities

For managers of facilities that conduct ultrasonography, these recommendations facilitate understanding about the necessity of preventive measures as an organization against musculoskeletal disorders and eyestrain, and indicate items that are required for prevention and responses against problems occurred.

(3) Recommendations for developers and manufacturers of equipment

For developers of ultrasonic diagnostic equipment and related equipment, these recommendations indicate items that should be improved to prevent occurrence of risks of musculoskeletal disorders and eyestrain regarding ultrasonic diagnostic equipment and related equipment.

1.5 Details of intended ultrasonic diagnostic equipment and examination

These recommendations target at health professions who continuously conduct single or several types of examinations of the abdomen, heart, breast, neck, and lower extremity using a stationary ultrasonic

diagnostic equipment (cart-based type, according to a classification of InMedica) but not compact ultrasonic diagnostic equipment like small notebook type.

1.6 Definition of terms

Terms used in these recommendations that require definition or important terms are defined as below.

Musculoskeletal disorders: means an injury or damage of muscles, skeletons, nerves, tendons, ligaments, joints, cartilages, and intervertebral disks caused by overload. Typical damages include neck-shoulder-arm disorder and low back pain.

Ultrasonic diagnostic equipment: means the main unit of ultrasonic diagnostic equipment. These recommendations target at a stationary ultrasonic diagnostic equipment (cart-based type, according to a classification of InMedica); in other words, target at the most common movable equipment with casters, but not compact ultrasonic diagnostic equipment like small notebook type equipment.

Sonographer: means persons who conduct ultrasonography operating ultrasonic diagnostic equipment and a probe.

Examinee: means patients or persons who have a medical examination of ultrasonography.

Examination table: means a piece of equipment on which examinees lie on or sit on during examination. Examination table includes consultation seats and beds.

Posture: includes the position of the neck, body trunk, upper and lower extremities and fingers and the angle of joints associated with examination.

Elevation of the arm: means elevation of the upper arm including both movement of flexion (movement of the shoulder joint elevating the upper arm forward anteriorly) and abduction (movement of the shoulder joint elevating the upper arm laterally) of the shoulder.

Display: means a main output device that shows ultrasonographic images when it is simply described as "display".

Operation panel: means a panel that has switches, knobs, levers and trackball, attached to ultrasonic diagnostic equipment.

Glare: means discomfort and difficulty in seeing caused by the existence of high-intensity light sources within the visual field. There are two types of glare. "Direct glare" is a situation that light from a light sources such as sunlight and lighting is directly seen, and "reflected glare" is a situation that light from a light sources reflected off a display makes it difficult for a person to see.

Illuminance: is a photometric quantity that indicates the intensity of light that illuminates a specific surface. In "Guidelines for Industrial Health Controls of VDT Operation" [6], illuminance (horizontal illuminance) for offices is prescribed as 300 lux and brighter. In the current status, the brightness of ultrasonic images

is very low in many cases, and illuminance of examination rooms varies from 10 lux and dimmer to 300 lux and brighter depending on facilities. Illuminance of examination rooms with illuminance-adjustable equipment seems to be about several lux to about 100 lux. Meanwhile, lighting of bright offices and stores is 1000 lux or brighter, and outdoor sunlight is 10,000 lux or brighter. Even if a room is brightly illuminated, whether a display is easily viewable depends on glare countermeasures, and performance of equipment.

Luminance: is a photometric quantity that indicates the intensity of light that is superficial lightness looked from a specific direction. A surface with high **luminance** is felt as glaring. Human visual sensitivity changes depending on light of the surroundings and environment; therefore, changes in relative **luminance** cause glare.

VDT task: Visual Display Terminal (VDT) means general equipment composed of display, keyboard etc., and personal computer is also included. The Ministry of Health, Labor and Welfare of Japan published "Guidelines for Industrial Health Controls of VDT Operation" to reduce mental and physical workloads of VDT workers and so that VDT workers can conduct their tasks without difficulties. Ultrasonography task can be considered as a kind of VDT task that includes a character of use of probes.

2. Risks of musculoskeletal disorders and eyestrain in ultrasonography tasks

In this section, risks due to posture that result in musculoskeletal disorders, risks of eyestrain, and issues regarding working hours that related with these disorders in ultrasonography operations are described.

2.1 Working postures

At first, working postures that cause musculoskeletal disorders are explained.

As the basis of judgment about risky postures and acceptable postures, ISO-11226 [7] and "Guidelines for Industrial Health Controls of VDT Operation" [6], which are ergonomic guidelines about working postures were used.

Postures that become a risk of musculoskeletal disorders in ultrasonography observed in our study are shown in Table 2-1. Assumable variations of postures for examinations are summarized in Table 2-2. Major postures and risks causing musculoskeletal disorders during ultrasonography operations recognized in our study are shown in Table 2-3. Hereinafter, major problems of postures are explained.

Table 2-1. Postures with a risk of musculoskeletal disorders observed in ultrasonography

Region	Risky Posture	Recommendation (reference)
Neck	Rotation	Avoidance of rotation (ISO-11226 [7])
	Extension (bending toward a direction of looking up)	Avoidance of extension (ISO-11226 [7])
Upper body	Inclination toward the right or left	Avoidance of inclination toward the right or left (ISO-11226 [7])
	Forward inclination	Avoidance of inclination at 60 degrees or more with limiting duration of a forward inclination at 20 degrees or more in short (ISO-11226 [7])
	Backward inclination	Avoidance of backward inclination without a support (ISO-11226 [7])
	Twisting	Avoidance of a twist of the upper body (ISO-11226 [7])
Lower back	Flexion (due to forward inclination of inappropriate sitting position)	Avoidance of flexion (ISO-11226 [7])
Upper arm	Elevation (abduction and flexion)	Avoidance of inclination at 60 degrees or more with limiting duration of a forward inclination at 20 degrees or more in short (ISO-11226 [7])
Wrist	Bending	Avoidance of a large bending of the wrist toward any directions (Seth et al., 1999 [8])
Grip	Grips other than a power grip to which strength is applied	Use of a power grip when strength is applied (Seth et al., 1999 [8])
Feet	The soles of the feet does not stably touch on the floor	Adjustment of the height of the chair so that the soles of the feet stably touch on the floor (VDT Guidelines [6])
	Crouching posture and a semi-crouching posture bending knees	Avoidance of a crouching posture and a semi-crouching posture (OWAS method; Karhu et al., 1977 [9] etc.)

Rotation of the neck

In examination of the heart that sonographers sit on the examination table, examination of the abdomen

that sonographers' upper body substantially incline toward examinees, and examination of the lower extremities that is conducted by a sonographer facing to the examinee, a posture that rotates the neck toward display occurs because the display is not placed in front of the sonographer. In ISO-11226, it is indicated that a posture with rotating the neck is not recommendable.

Extension of the neck (inclination toward a direction to look up)

When the position of a display is too high or when lower regions such as the lower extremity are examined, a posture facing the head upward occurs because the display is placed in a high position. Regarding of backward and forward inclination of the neck without a support, in ISO-11226, it is described that backward inclination (inclination toward a direction to look up) of the neck is not recommendable. On the other hand, it is described that forward inclination of the neck at up to 25 degrees is acceptable; however, duration of a posture that inclines the neck more than 25 degrees should be kept in minimum.

Inclination of the upper body to the right or left

In examination of the abdomen, heart, and lower extremities, a posture inclining the sonographer's upper body toward the examinee occurs when a probe is applied to an area distant from the sonographer. Inclination of the upper body is a risk of a lower-back injury. In ISO-11226, it is indicated that an inclination of the upper body toward the right or left direction is not recommendable.

Inclination of the upper body backward and forward

When sonographers in a standing position examine examinees' abdomen or organs in the left side, or when sonographers examine lower extremities of examinees in a standing or sitting position, a posture with forward inclining occurs in sonographers. Forward inclining of the upper body is a risk of a lower-back injury. In ISO-11226, it is indicated that forward inclining up to 20 degrees is acceptable, but postures with further inclining should be limited in a short time. In addition, it is described that posture with a curved lower back is not recommendable under any circumstances.

In examination of the lower extremities that an examinee is in a supine position, a posture that the upper body inclines backward may occur because of a large distance between the ultrasonic diagnostic equipment and the examined region. A posture inclining backward without a support (backrest) is not recommendable (ISO-11226).

Twist of the upper body

When sonographers sitting on the end of an examination table examine the heart of examinees, a posture twisting the upper body toward the examinee occurs. In ISO-11226, it is indicated that a twist of the upper body is not recommendable even at a small angle.

Elevation of the upper arm holding a probe

In examination of the abdomen, breast, neck, lower extremities, and heart, postures that elevate the

hand and arm holding a probe without support occur frequently. Elevation of the upper arm at a great angle (abduction and flexion) is a risk of shoulder injury. In ISO-11226, it is recommended to maintain the angle between the body trunk and upper arm less than 20 degrees, and it is indicated to minimize duration of such posture when the angle becomes larger than 20 degrees.

Elevation and extension of the arm of the operation panel side

When the upper body is inclined to an examinee side on an examination table in examination of the abdomen and heart, or when sonographers are in a greatly forward inclining posture or in a crouching posture in examination of the lower extremities, a posture that lifts and extends the upper extremity of the panel side occurs because an operation panel is distant. In a similar manner to the elevation of the upper arm holding a probe, a posture in that an angle between the upper arm of the operation panel side and the body trunk becomes 20 degrees or larger should be kept in minimum duration. It is recommended to arrange the position of button and knobs of the operation panel to the height closer to the height of the elbow [10], and a working area in a horizontal plane (An example of a horizontal plane: Figure 2-1) should be considered [11) 12)].

Gripping of a probe and bending of the wrist

When bending angle of the wrist either directions, palmar-dorsal flexion or radial-ulnar flexion, is larger, strains become larger. When strength is applied, gripping ways other than a power grip (a gripping way of hammer), that grips with only fingers, cause strains on a hand and fingers (Figure 2-2). In ultrasonography, an arm holding a probe becomes extended and only the wrist may substantially bend when a probe is applied to a distant region. The bending of the wrist may be reduced by a flexible gripping way with the tips of fingers in some cases; however, it is necessary to avoid giving strong power, and especially to avoid repetition of the gripping way in such cases.

Unstable foothold

When the height of chairs that the sonographer sits on is too high, a posture that cannot stably touch the floor with the soles of feet occurs. In "Guidelines for Industrial Health Controls of VDT Operation" (Ministry of Health, Labor and Welfare, 2002 [5]), a posture stably touching the floor with the soles of feet is recommended. It is considered that stability of the feet is especially important in ultrasonography during which the upper body may be substantially inclined.

Working in a standing position

Operation of ultrasonography may be conducted by sonographers in a standing position. Inclination and twist of the upper body may also be a risk of musculoskeletal disorders ~~even~~ in a standing position. Risks of inclination and twist of the neck are similar as that of sitting position. When ultrasonography of examinees lying down on an examination table of the height of a common bed is conducted by sonographers in a standing position, substantial forward inclination or twist of the upper body may occur.

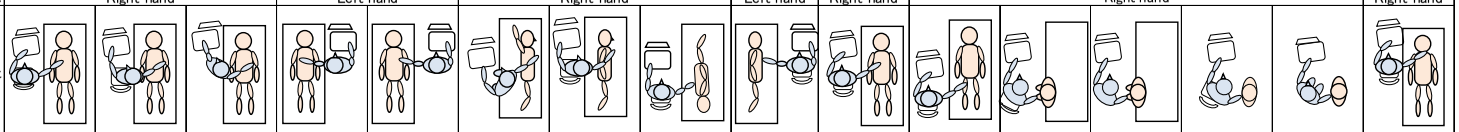
Prolonged work in a standing position has greater workloads than that in sitting position on a chair or operation with insertion of a task in a sitting position on a chair.

Table 2-2. Postural factors of ultrasound technicians and examinees, and their combinations

◎: Recognized in this study; ○: Within the scope of the assumption

Examinee	Posture	Supine position, lateral position, Gatch up						Sitting position						Standing position					
	Direction	Regular (The head comes to a left side of a sonorapher)		Reversed (The head comes to a right side of a sonorapher)				Facing to sonographer						Facing to sonographer					
Sonographer	Posture	Sitting position on a chair, sitting on an examination table	Standing position	Sitting position on a chair, sitting on an examination table	Standing position	Sitting position on a chair, sitting on an examination table	Standing position	Sitting position on a chair		Standing position		Crouching position		Sitting position on a chair		Standing position		Crouching position	
	Probe	Right hand		Right hand		Left hand		Right hand	Left hand	Right hand	Left hand	Right hand	Left hand	Right hand	Left hand	Right hand	Left hand	Right hand	Left hand
Region examined	Neck	◎	○					Thyroid examination											
	Breast	◎	○																
	Heart	◎	○	◎	○	◎	○												
	Abdomen	◎	○			◎	○												
	Lower extremity	◎	○					◎				◎		◎		◎		◎	
Remarks		Common	Common standing position	Relatively common for reverse examinee's position and heart examination with the right hand		Heart and abdomen examinations with a probe in the left hand		Lower extremity examination conducted for examinees in a sitting position				Lower extremity examination conducted for examinees in a sitting position		Lower extremity examination conducted for examinees in a standing position		Lower extremity examination conducted for examinees in a standing position		Lower extremity examination conducted for examinees in a standing position	

Table 2-3. Major working postures and risks in ultrasonography

Examination region	Abdomen				Heart				Breast	Lower extremity					Neck
	Right-central organs	Left l organs	Right-central organs	Left organs											
Posture of examinee	Supine position				Supine/ lateral position				Supine position	Supine position	Sitting position		Standing position		Supine positio
Posture of sonographer	Sitting position on a chair	Standing position	Sitting position		Sitting on an examination table	Sitting position			Sitting position	Sitting position	Sitting position	Standing-crouching position	Sitting position	Standing-crouching position	Sitting position
Probe	Right hand			Left hand		Right hand		Left hand	Right hand	Right hand					Right hand
Layout															
Burden on eyes	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Rotation of the neck		○	○	○		○	○				○	○	○	○	
Elevation of a probe side arm	○	○	○	○	○	○	○	○	○	○					○
Elevation of the arm on an operation panel		○	○	○		○	○				○	○	○	○	
Bending and twisting of the wrist	○	○	○	○	○	○	○	○	○		○	○	○	○	○
Pressing and continuously immobilizing a probe	○			○		○	○	○	○						
Inclination of the upper body		○	○	○		○	○				○				
Forward bending of the upper body			○									○	○	○	
Twist of the upper body						○									
Instability of the feet		○		○		○	○					○		○	
Unstable sitting position						○									
Standing position			○									○		○	
Other								No right hand support	No left hand support	No right hand support			Crouching posture		Crouching posture	

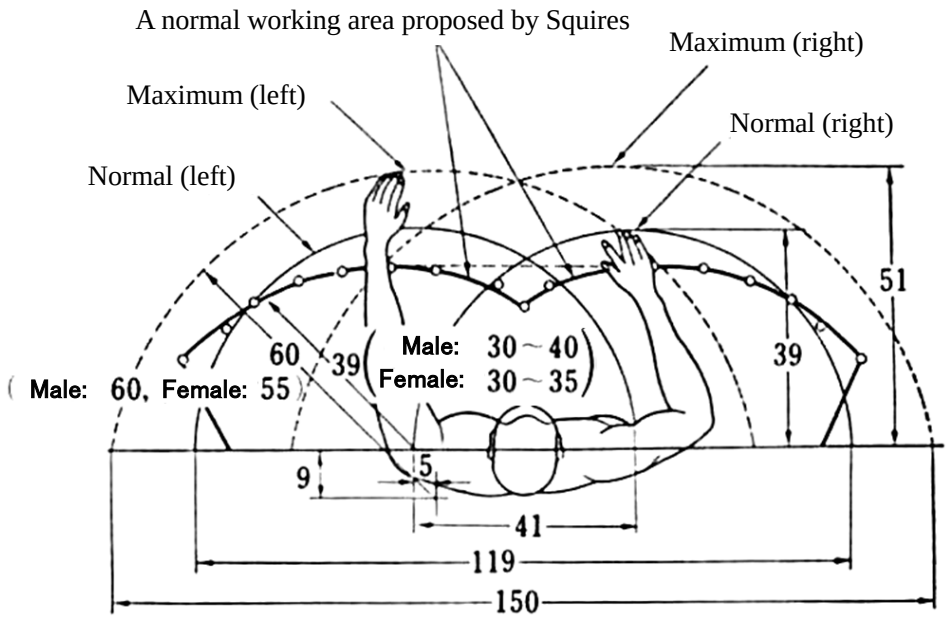


Figure 2-1. An example of a horizontal plane working area [13]. Grip operable distances for Japanese are indicated in parentheses. In design and layout of examination system, this working area should be considered. There are usual (normal) working area and maximum working area. You can readily know your own working area by having a working posture and measuring distances with a tape measure. A range that hand can reach without effort and elevation of the upper arms is the usual working area. For tasks that are conducted with holding a probe, manipulation of operation panel, and other frequently conducted tasks, it is necessary to place the operation targets within the usual working area.

Power grip

is the safest way of gripping with less straining to allow easily exerting strength.

Two-point pulp pinch

allows precise works, but have more burdensome when the works are repeated with exertion of strength or continue for a prolonged time.

Lateral pinch

External precision

Internal precision

Hook grip

Palm pinch

Finger press

Other ways of gripping

Various ways of gripping are used for depending on different precision of the work and what is the subject to be gripped, but any of them are heavier strains than power grip. Especially, strains due to repeated use under conditions associated with weight or exertion of strength or prolonged use is substantial.

Figure 2-2. Classification of the way of gripping

General classification of the way of gripping. A power gripping results in the least straining when strength is exerted. (Adapted from Freivalds & Niebel, 2009. Niebel's methods, standards and work design [14] with partial modification)

2.2 Eyestrains in ultrasonography

Based on "Guidelines for Industrial Health Controls of VDT Operation" (Ministry of Health, Labor and Welfare, 2002 [5]), risk of eyestrain for sonographers is shown in this section. Ultrasonography is a VDT operation that has a risk of eyestrain caused by prolonged operation. In addition, there are risk factors of particular eyestrains and eyestrain in sonographers shown in Table 2-4.

Table 2-4. Risks of eyestrain that are characteristic of ultrasonography tasks

Risk	Description
(1) Tasks associated with continuous gazing on a screen	Tasks that continuously gaze images (still images and moving images) are repeatedly conducted for a prolonged time.
(2) Lighting without dimmer control, Too dark lighting	Examinations are often conducted in a low illuminance room, and lighting of many examination rooms does not achieve 300 lux that is illuminance recommended for VDT operations. In a too dim room, a display causes substantial change in brightness in the visual field and results in glare.
(3) Display in a unsuitable position	The height, position and angle of displays are not appropriately adjusted in many cases.

2.3 Working hours

2.3.1 Problems in working hours of ultrasonography

As the reason that musculoskeletal disorders become a problem in sonographers today, it is considered that there are problems related to management of working hours indicated in Table 2-5.

Table 2-5. Problems in management of working hours in ultrasonography

Problem	Description
(1) Management of continuous working hours	Regardless of straining work due to postures, management of continuous working hours is not adequately conducted.
(2) Management of working hours a day	There are high needs for examinations, working hours in a day become longer because of shortage of staff, and management of working hours is not adequately conducted.

As mentioned above, conditions of working postures in ultrasonography operation are very poor as compared with computer works in offices, etc. Although sonographers can control work pace by themselves to some extent, there is a problem that the examinations are conducted with due considerations to examinees, and at least the works are not self-directive (cannot be conducted in their own pace) as compared with computer works in offices including document preparation and information collection. In

addition, there are high needs for examinations; therefore, it is considered that time intervals between examinations become shorter to avoid waiting examinees and other reasons.

2.3.2 Investigation by the Ministry of Health, Labor and Welfare, etc.

Accumulative effect due to frequent or prolonged operations is associated with musculoskeletal disorders and eyestrain. According to investigation by the Ministry of Health, Labor and Welfare, the most popular answer about the average working hours a day of workers engaging in VDT operation in Japan was about 4 hours (Ministry of Health, Labor and Welfare, Study in 1998). It is considered that VDT operations are not really problem, when working hours does not greatly exceed 4 hours, and management of continuous working hours and working environment is sufficiently controlled (Japan Industrial Safety & Health Association, 2003 [15]).

2.3.3 Investigation by the Research and Development Team

According to the results of questionnaire investigation implemented by the Research and Development Team to sonographers, answers that the average examination hours in an average day is less than 4 hours was 45%, 4 hours and longer was 39%, 5 hours and longer was 26%, 6 hours and longer was 14% in this study (Figure 2-3). For examination hours in a busy day, answers in a range of 3-6 hours were 50%, 6 hours and longer was 43%, 7 hours and longer was 26%, and 8 hours and longer was 13%.

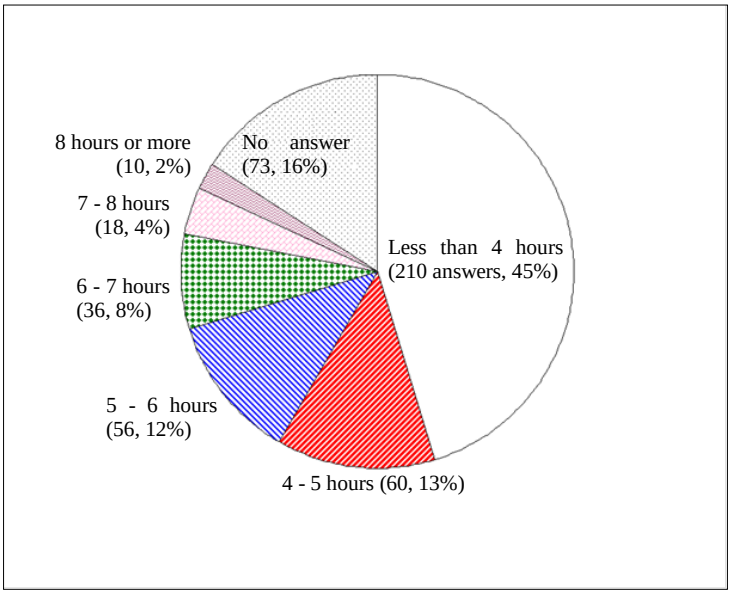


Figure 2-3. Proportion of answers about average examination hours in a day

3. Countermeasures for musculoskeletal disorders and eyestrains in ultrasonography tasks

Risks of musculoskeletal disorders and eyestrain in ultrasonography are associated with not only ergonomic design of ultrasonic diagnostic equipment but also use of examination table and chair used around the equipment, environment of examination room, working hours and frequency, and working methods. Therefore, it is desired that countermeasures to reduce these risks would be promoted in cooperation among three parties, i.e., managers of related facilities, manufacturers of ultrasonic diagnostic equipment and related equipment, and sonographers themselves.

It is desired for manufacturers to propose and provide equipment that considered the current status of examination environment and working postures, as an integrated design that includes related equipment such as an examination table. In addition, the examination environment is built by the facility. Accordingly, even if the design of ultrasonic diagnostic equipment is excellent, the properties would be wasted when the space of the examination room and auxiliary instruments such as a chair and examination table are inappropriate. Also, even if the environment and methods of operation are improved in some degree, a risk of musculoskeletal disorders would become greater when working hours and the number of examinations are not appropriately managed. It is necessary that the facility implements countermeasures to avoid prolonged work and repeated works as much as possible when reduction of workloads on sonographers is difficult because of design of equipment and limitation of environment.

Here, targets for improvement that should be promoted in cooperation among three parties, sonographers, managers of facilities and manufacturers, and conditions that enable to reduce risk of musculoskeletal disorders.

3.1 Working posture

Regarding postures including a sitting position and standing position that are taken by sonographers in ultrasonography, less straining and ideal conditions are indicated below. Postures without risks of musculoskeletal disorders are postures that have less unpleasant sensation and discomfort due to unnatural postures, are unlikely to cause fatigue, avoid waste of motion, and, in general, are usually good postures in terms of quality and efficiency of the tasks.

3.1.1 Less-straining posture in sitting positions on a chair

When taken together previous results of research on VDT operations and on workloads (risks of musculoskeletal disorders), less-straining working postures in ultrasonography tasks are below (Figure 3-1, Table 3-1). These indicate ideal postures; therefore, it may difficult to arrange the region to apply a probe within a working area indicated in the figure depending on the region examined. However, it would be effective to set these postures as one of goals for improvement.

(1) The height of sonographer's chair is appropriately adjusted and the soles of footwear stably touch on the floor with bending the knee joint at about 90 degrees.

The feet are unstable because chairs are too high in some cases in the present circumstances. When examination tables are too high, the feet become unstable in some cases because there is no other choice to heighten the chair. It is ideal to improve the height of examination tables and chairs, and then, to improve the conditions by adjusting the ultrasonic diagnostic equipment and chair accordingly. As the second best measures, use a footrest that can stably hold the feet.

(2) Display is placed in a position that allows downward gaze of about 10 degrees in the front of sonographers. When gaze continues, the neck faces the front without a left-right rotation and forward-backward inclination.

There are cases that the neck is rotated toward the ultrasonic diagnostic equipment side to look at a display, or to look up a display placed at the high position in the present circumstances. It is necessary to improve the position of the display or a posture of the sonographer's upper body.

(3) The spine is straightened up without bending the low back and forward inclination of the upper body. Also, the low back to the upper body is bilaterally symmetric without right or left inclination or rotation (twist) of the upper body.

There are cases that the upper body inclines toward an examinee's side, that the low back is twisted by sitting on an examination table, and that the upper body greatly inclines forward in lower extremity examination in the present circumstances. Improvement of ultrasonic diagnostic equipment and related equipment, and examination methods is necessary.

(4) An operation panel can be manipulated with small elevation (20 degrees or less) of the upper arm manipulating the operation panel and bending the elbow joint at about 90 degrees. A working area is considered to achieve this (Figure 2-1). The forearm to wrist is supported during the operation.

There are cases that the arm is stretched with elevation of the upper arm because an operation panel is far from the sonographers in the present circumstances. It is necessary to reduce elevation of the arm and to avoid a posture that the upper body of the sonographer inclines toward the examinee's side that causes the elevation through improvement of equipment including the adjustable range for the position of operation panels and improvement of examination methods.

(5) A probe can be manipulated with small elevation (20 degrees or less) of the upper arm holding the probe and bending the elbow joint at about 90 degrees. A working area is considered to achieve this (Figure 2-1). The forearm or wrist is supported.

There are cases that the upper arm is elevated because regions to be examined are far in the present circumstances. The elevation of the arm becomes larger when a relationship between the height of the chair and examination table is inappropriate. It is necessary to develop a method to bring the regions examined closer to the sonographer, develop armrests to support the elevated arm, and to improve examination

methods, etc.

(6) The wrist holding the probe has no bending to any directions. The probe can be held with power grip (a gripping way of hammer) at least when strength is applied (Figure 2-2).

Bending of the wrist may become larger to apply the probe at various angles with fully stretching the arm because examined regions are far in the present circumstances. Improvement of the posture with fully stretched arm that causes bending of the wrist, improvement of equipment such as probes to reduce strains on the hands and fingers, and improvement of examination methods are necessary.

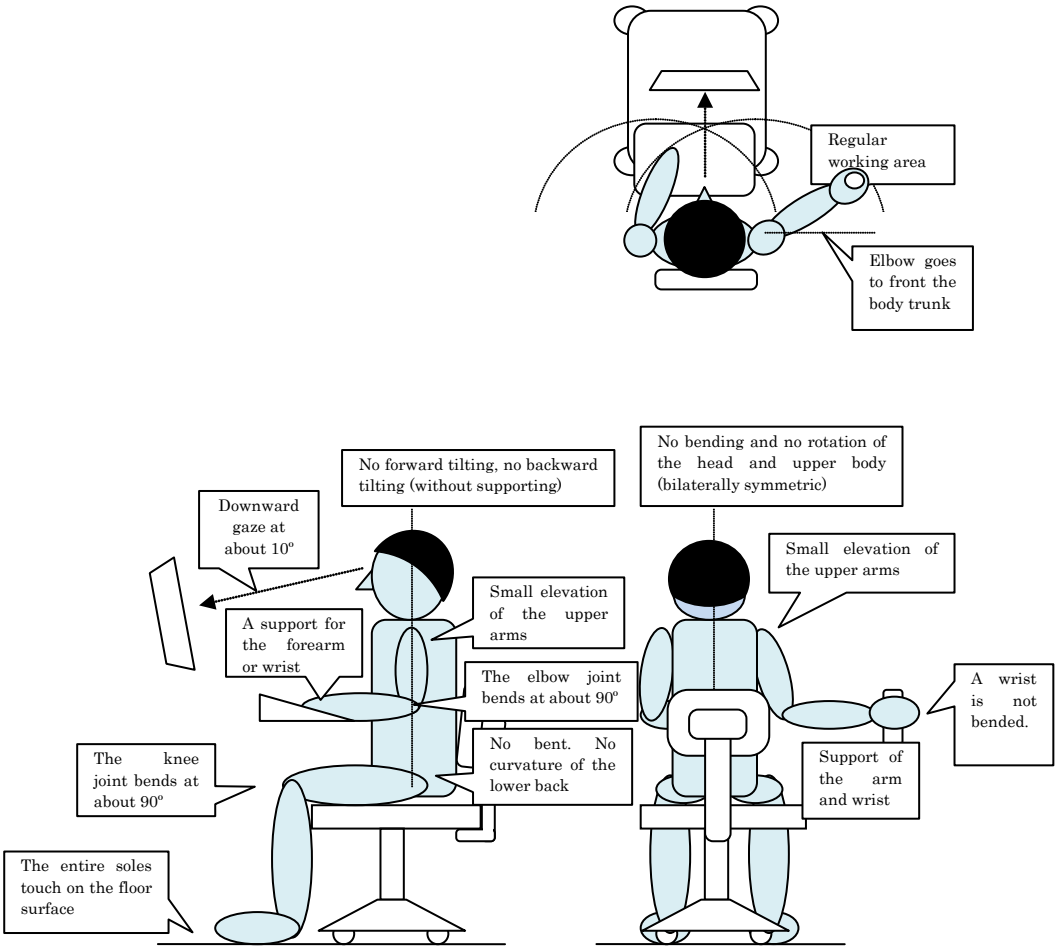


Figure 3-1. An ideal posture for examination task to reduce workloads

A schematic diagram of an ideal posture for examination task to reduce workloads in ultrasonography based on "Guidelines for Industrial Health Controls of VDT Operations"

Table 3-1. An ideal posture for examination task to reduce workloads in ultrasonography in sitting position based on "Guidelines for Industrial Health Controls of VDT Operations" (Ministry of Health, Labor and Welfare, 2002 [5])

Conditions of ideal posture	Description
(1) The height of sonographer's chair is appropriately adjusted and the soles of footwear stably touch on the floor with bending the knee joint at about 90 degrees.	The feet are unstable because chairs are too high in some cases in the present circumstances. When examination tables are too high, the feet become unstable in some cases because there is no other choice to heighten the chair. As the second best measures, use a footrest that can stably hold the feet.
(2) Display is placed in a position that allows downward gaze of about 10 degrees in the front of sonographers. When gaze continues, the neck faces the front without a left-right rotation and forward-backward inclination.	There are examples that the neck is rotated toward the ultrasonic diagnostic equipment side to look at a display, or to look up a display placed at the high position in the present circumstances.
(3) The spine is straightened up without bending the low back and forward inclination of the upper body. Also, the low back to the upper body is bilaterally symmetric without right or left inclination or rotation (twist) of the upper body.	There are cases that the upper body inclines toward an examinee's side, that the low back is twisted by sitting on an examination table, and that the upper body greatly inclines forward in lower extremity examination in the present circumstances.
(4) An operation panel can be manipulated with small elevation (20 degrees or less) of the upper arm manipulating the operation panel and bending the elbow joint at about 90 degrees. A working area is considered to achieve this (Figure 2-1). The forearm to wrist is supported during the operation.	There are cases that the arm is stretched with small elevation of the upper arm because an operation panel is far from the sonographer in the present circumstances.
(5) A probe can be manipulated with small elevation (20 degrees or less) of the upper arm manipulating the operation panel and bending the elbow joint at about 90 degrees. A working area is considered to achieve this (Figure 2-1). The forearm or wrist is supported.	There are cases that the upper arm is elevated because regions to be examined are far in the present circumstances. The elevation of the arm becomes larger when a relationship between the height of the chair and examination table is inappropriate.
(6) The wrist holding a probe has no bending to any directions. The probe can be held with power grip (a gripping way of hammer) at least when strength is applied. (Figure 2-2)	Bending of the wrist may become larger to apply the probe at various angles with fully stretching the arm because examined regions are far in the present circumstances.

3.1.2 Reduction of workloads caused by working in a standing position

Operation of ultrasonography may be conducted by sonographers in a standing position. In the case of standing positions, (2) to (6), except (1), indicated in "3.1.1 Less-straining posture in sitting positions on a chair" are also applied to standing positions as well as to sitting positions on a chair. In other words, it is desired that the posture is straight and bilaterally symmetric without bending (flexion or extension) of the upper body and neck or elevation of the upper arm.

When examinees lying down on an examination table are examined in a standing position, forward bending or twist of the upper body substantially may occur when the examination table cannot be adjusted higher. It is desired to use an examination table that can be adjusted higher, and to use an operation panel and display that are adjustable to appropriate height for operations conducted in a standing position.

A standing position may be selected to reach a probe to a distant region. In such cased, it is considered that problems of postures including forward inclination often occur; therefore it is desired to optimize the height of examination tables. However, the unnatural position may not be completely avoided by adjustment of the height only. There is an underlying problem that the examined region is distant; therefore, countermeasures against the issue are desired.

Given workloads and fatigue of prolonged works, in general, it is desired to conduct examinations in a good sitting position on a chair as much as possible. Changing and switching of postures are effective for prevention of musculoskeletal disorders, it is ideal to develop condition to work in a natural posture either a sitting position on a chair or standing position in terms of injury prevention. If works in a standing position continue for a prolonged time, it is desired to insert tasks that can be performed in a sitting position on a chair or a rest.

3.1.3 Selection of examinees' body position and examination methods considering workloads on sonographers

The body position of examinees and examination methods should be selected with giving consideration to postures and workloads of sonographers within a range that does not decrease the accuracy of the examination.

In examination of blood vessels of the lower extremities, for example, workloads of sonographers is smaller when examinees are placed in a supine position and the sonographers examine in a sitting position on a chair than when examinees are in a sitting position or standing position and the sonographers examine in a crouching posture. Also, in heart examination and examination of distant regions of the abdomen conducted to examinees in a lateral position, an approach to bring a region far from the sonographer to closer by switching the direction of supine position (a right and left direction and head and feet direction) should also be considered depending on conditions.

In heart examination, there is a method that conducts examinations in a lateral position so that the examinee's head is placed in a further side and the examinee's back faces to the sonographer side, and another method that takes a lateral position so that the examinee's head is placed in a closer side and the examinee's chest region faces to the sonographer side, and the sonographer conducts examinations without substantially elevating the upper arm of the sonographer and a posture that overlying the examinee (Table 2-2). In addition, there is a method for heart and abdomen examinations that an sonographer holds a probe in the left hand and examines without substantially elevating the upper arm (Table 2-2). It would be effective to prepare such options according to the condition of examinees.

3.2 Measures for eyestrains

Ultrasonography is a VDT operation, and "Guidelines for Industrial Health Controls of VDT Operation" (Ministry of Health, Labor and Welfare, 2002 [5]) issued by the Ministry of Health, Labor and Welfare can be used as the standards for prevention of injury involved with ultrasonography. The basis of the countermeasures to prevent eyestrains is indicated based on these guidelines in this section. The outline of the measures is summarized in Table 3-2. It is considered that visual working environment that is taken countermeasures to prevent eyestrains is a good environment for quick and generally precise visual recognition and is also good in terms of quality and efficiency of the tasks.

(1) Avoid tasks that use a display and probe and continue for one hour or longer.

Insert a break (a rest or other tasks that does not gaze a display) at least 10 minutes or longer after continuous work for one hour.

(2) Increase illuminance within a range that images can be clearly viewed.

Dimmer control equipment is necessary. Illuminance should be adjusted so that surrounding brightness become approximately equal to the brightness of display that is adjusted considering adequate viewability. Reference levels of illuminance is shown in the next section. In Guidelines for VDT Operations [5], a standard of illuminance (horizontal illuminance) VDT is 300 lux or brighter. It is desired to lighten 300 lux or brighter as a target within a range that images can be clearly viewed in terms of safety and ease in tasks like reading paper documents. Illuminance should be controllable independently for each booth. If glare occurs by lightening, take countermeasures against it (following (3)).

(3) Take countermeasures against reflected glare that caused by lighting reflected on a display.

Countermeasures against reflected glare include use of a louver (a cover for lighting equipment), placing a display at right angle to a window, adjusting the position of display to avoid reflection of the lighting on the display.

(4) Take countermeasures against direct glare that is lighting and natural light or reflection of it entering into the eye directly.

Countermeasures against direct glare include adjustment of a position of a display, use of indirect lighting, light shielding of windows including curtains, blinds, screens, etc.

(5) Adjust brightness, contrast, etc. of displays to improve visualization and to reduce glaring. Consider that changes in brightness or contrast may make it difficult to clearly observe the small difference of luminance especially in very low or very high luminance level. Also consider that adjustment of brightness or contrast is not reflected in the images stored in the server.

(6) Adjust the positional relationship between display and operators appropriately.

Place a display at easily viewable position with using a distance of 40 cm or more as a target. Right and left position shall be a direct front, and height shall be suitable for downward of about 10 degrees (the height of the eyes corresponds to the height of the top end of the display).

(7) Avoid direct blowing of a wind from air conditioning, etc. against the face of sonographers.

(8) Conduct appropriate visual correction by eyeglasses, etc.

Regarding eyestrains, points to be particularly paid attention in ultrasonography include operations gazing the display repeated for a prolonged time. In addition, there are many problems in especially lighting. When there is a great change of brightness within the field of view and there is glare parts, it causes eyestrains. Too low illuminance causes prominence of brightness (glare) of displays.

Another problem regarding lighting is that the position and angle of display may be changed according to changes in sonographers' postures in ultrasonography, and optimum adjustment as glare countermeasures may become difficult. Therefore, it is especially necessary for examination rooms for ultrasonography to take countermeasures against glare including indirect lighting or louver for lighting.

Table 3-2. Outline of measures for eyestrains based on "Guidelines for Industrial Health Controls of VDT Operation" (Ministry of Health, Labor and Welfare, 2002 [5])

Item		Outline of countermeasures
Working hours		- Avoidance of VDT operations that continue for one hour or longer.
Illuminance		- Increase illuminance within a range that images can be clearly viewed. (The target level of improvement including display-equipment is 300 lux)
Glare countermeasures		- Countermeasures against reflected glare and direct glare.
Display	Position	- Place a display at an easily viewable position with using a distance of 40cm as a target. - Right and left position shall be a direct front, and height shall be suitable for slightly downward gaze.
	Brightness and contrast	- Adjust to improve visualization and to reduce glaring. Consider that function of luminance-expression (Gamma-curve) may change, and adjustments are not reflected in the images stored in a server.
Others		- Avoid direct blowing of a wind from air conditioning, etc. against the face of sonographers.
		- Conduct appropriate visual correction by eyeglasses, etc.

3.3 Measures for working hours

Implementation of following measures and improvement is required in facilities where ultrasonography and related computer tasks may continue one hour and longer. The outline is summarized in Table 3-3.

(1) Management of continuous working hours

It is necessary to avoid examination task that continues one hour and longer, and to manage so that 10-15 minutes break or tasks without holding a probe and a steady gaze of a display can be inserted between one-hour operations at a maximum. Implementation of followings is required.

1) Insert rest of 10 minutes or longer every hour or tasks without holding a probe and that can give the eyes a rest (without a steady gaze of a display).

2) Insert tasks that are conducted away from the ultrasonic diagnostic equipment, such as data entry task using a computer, every single examination. Insertion of another task to change the posture to a more comfortable position such as data entry task have a small risk as compared with when examinations of several examinees are continuously implemented.

3) When insertion of break is difficult, insert movements such as change of the posture or light stretching

exercise for any length of time.

(2) Management of working hours or the number of examinations per a day

It is necessary to manage to avoid too long of a task holding the probe facing the ultrasonic diagnostic equipment by setting the upper limit of working hours or the number of tasks per a day.

According to the results of questionnaire investigation conducted by the Research and Development Team of the Japan Society of Ultrasonics in Medicine, the examination that has the longest average amount of time required for a single examination was examination of blood vessels of the lower extremity, and the time required was 35 minutes (the longest case was 90 minutes). Examination of heart and abdomen took 25 minutes (60 minutes at longest), and 18 minutes (60 minutes at longest) on an average, respectively. Considering this current status, if reduction of work-strains and change of posture are conducted in an interim period between examinations, it can be considered as breaks of tasks. In such cases, examination time for single examinee can be considered as single continuous work without break.

Regarding setting of the upper limits of total working hours and the number of examinations per a day, it is considered as below on the assumption that single continuous working hour is appropriate. It is considered that ultrasonography has especially significant risk among VDT operation; therefore, the upper limit of working hours a day would be 6.4 hours when break is set as 15 minutes every one hour, and working hours a day is set as eight hours. The upper limit of the number of examinations on the basis of this differs according to a length of time required for single examination, for example, about 25 cases if it takes 15 minutes for an examination, and about 12 cases if it takes 30 minutes for an examination.

(3) Reduction of work-strains by working rotation

It is also effective to reduce the number of the same types of repetitive tasks conducted by specific individual by working rotation.

(4) Avoidance of many times or prolonged implementation of highly straining examinations

It is desired to avoid that the same sonographer implements many times of repetitive tasks and prolonged tasks for examinations that can be done only in unnatural postures, examinations in a facility that cannot optimize working posture, and examinations that requires displays causing eyestrains due to indication with poor viewability.

Table 3-3. Recommendation regarding working hours

Item	Countermeasure
(1) Management of continuous working hours	1) Insert rest 10 minutes or longer every hour or tasks without holding a probe and that can give the eyes a rest (without a steady gaze of a display). 2) Insert tasks that are conducted away from ultrasonic diagnostic equipment, such as data entry task using a computer, every single examination. Insertion of another task to change the posture to a more comfortable position such as data entry task have a small risk as compared with when examinations of several examinees are continuously implemented. 3) When insertion of break is difficult, insert movements such as change of the posture or light stretching exercise for any length of time.
(2) Management of working hours or the number of examinations per a day	Manage to avoid too long of a task holding the probe facing the ultrasonic diagnostic equipment by setting the upper limit of working hours or the number of tasks per a day.
(3) Reduction of work-strains by working rotation	Reduce the number of the same types of repetitive tasks conducted by specific individual by working rotation.
(4) Avoidance of many times of or prolonged implementation of highly straining examinations	Avoid that the same sonographer implements many times of repetitive tasks and prolonged tasks for examinations that can be done only in unnatural postures, examinations in a facility that cannot optimize working posture, and examinations that requires displays causing eyestrains due to indication with poor viewability.

3.4 Examination room, ultrasonic diagnostic equipment, and related equipment to prevent musculoskeletal disorders and eyestrain

In this section, specifications of examination rooms, ultrasonic diagnostic equipment, chairs, examination tables to realize ideal less-straining postures described in a section 3.1 are described. It is considered that conditions of less-straining environment and conditions for sonographers are conditions that give less discomfort and uncomfortable feeling due to unnatural postures, lessen the waste of motion, and are also good conditions for quality and efficiency of examinations.

3.4.1 Examination rooms

In this section, specifications of examination rooms including the area, lighting, and air conditioning are described. The postures of sonographer are determined according to a combination of the position of an operation panel and display, the position of an sonographer and the height of a chair, and the position and height of examinee on an examination table. It is necessary that examination rooms have enough space that does not restrict to provide appropriate layout. In addition, it is necessary to take measures against lighting of examination rooms and glare to reduce eyestrains.

3.4.1.1 Area of examination rooms that enables suitable adjustment of layout

Enough space is necessary in examination rooms that allows optimization of positional relationship among sonographer, ultrasonic diagnostic equipment, and examination table according to the content of examination implemented and equipment used. When the area of the examination room has a limitation, it is necessary to use an ultrasonic diagnostic equipment and examination table having appropriate adjustment functions that can compensate the limitation. The outline of recommendation regarding the area of examination rooms is summarized in Table 3-4. Meanwhile, here, the followings are explained on the assumption that a probe is held in the right hand and equipment is operated with the left hand.

(1) Depth of examination rooms

It is necessary to secure a depth of the examination room at least that allows to place the top (the back side) of an operation panel on the top edge of the back side of an examination table without touching the back of main unit of ultrasonic diagnostic equipment to a wall (Figure 3-2). It is desired to have enough room for adjustment of the position and direction of ultrasonic diagnostic equipment.

(2) Width of examination rooms

Enough space where the sonographer can move using a chair with casters according to tasks is required.

It is necessary to consider a left side space to secure an angle of an operation panel when the operation panel cannot be drawn closer to appropriate position unless adjusting the angle of main unit of ultrasonic diagnostic equipment, and consider a space for an examinee and sonographer who is facing to the examinee when an examinee stands at the left of an examination table, in examination of such as lower extremity. When examination is conducted with carrying in a stretcher, it is necessary to secure enough space of the

width of the examination room more than the width of the stretcher in addition to the above.

(3) Ensuring legroom

It is necessary to ensure a space and to avoid placing things under examination tables and operation panels, as legroom for the sonographer.

It is desired to distribute and organize power cables of equipment, etc. to avoid hindering movement of the ultrasonic diagnostic equipment.

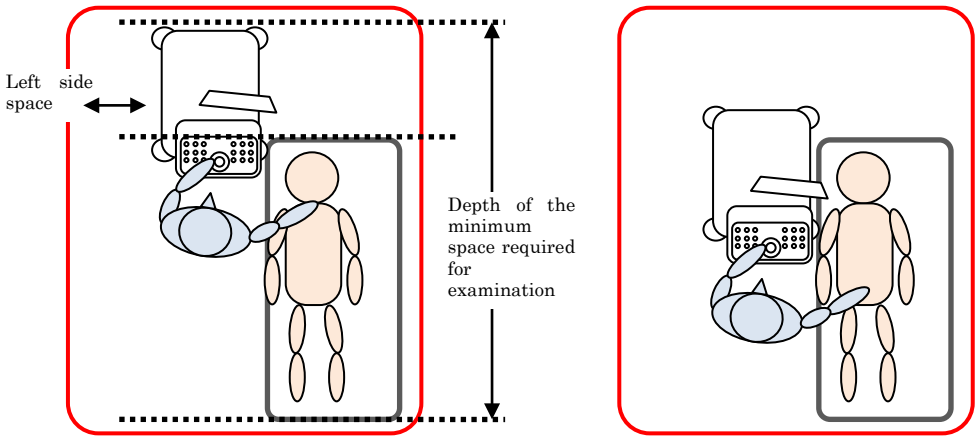


Figure 3-2. Area of examination rooms

Table 3-4. Outline of recommendation items regarding the area of examination rooms

Item	Outline
(1) Depth	- Depth of the examination room at least that allows to place the top (the back side) of an operation panel on the top edge of the back side of an examination table without touching the back of main unit of ultrasonic diagnostic equipment to a wall. - Enough room for adjustment of the position and direction of ultrasonic diagnostic equipment.
(2) Width	- Enough space where the sonographer can move using a chair with casters according to tasks. - Consider a left side space to secure an angle of an operation panel when the operation panel cannot be drawn closer to appropriate position unless adjusting the angle of main unit of ultrasonic diagnostic equipment, and consider a space for an examinee and sonographer who is facing to the examinee when an examinee stands at the left of an examination table, in examination of such as lower extremity. - When examination is conducted with carrying in a stretcher, securement of enough room of the room width more than the width of the stretcher in addition to the above.
(3) Legroom	- Ensure a space and avoid placing things under examination tables and operation panels. -Distribute and organize power cables of equipment, etc. to avoid hindering movement of the ultrasonic diagnostic equipment.

3.4.1.2 Lighting of examination rooms

Recommended items regarding lighting are shown below. The outline is shown in Table 3-5.

(1) Illuminance of examination rooms

Use of adjustable illuminance (dimmer control) is desirable for the examination room of sonography that accurate visual inspection of images with various brightness is needed. Adjustment to make surrounding brightness (wall etc.) and the averaged brightness of the display approximately equal is recommended. The

illuminance of light, the reflectance of surrounding wall, and other light sources or reflection affect the surrounding brightness. If light sources such as sunlight and lighting is directly seen, glare countermeasures should be implemented. Table. 3-6 shows the approximate reference values of illuminance. It is very important that illuminance is adjustable for each booth.

Illuminance of 300 lux and brighter lighting is recommended in "Guidelines for Industrial Health Controls of VDT Operation" (Ministry of Health, Labor and Welfare, 2002 [5]). Considering the comfort in tasks such as reading paper documents and safety, it is desired in the future to make the room illuminance brighter with giving consideration to whether ultrasonographic images are clearly visible, and to viewability of indicator lamps of equipment. Horizontal illuminance on an operation panel of 300 lux and brighter gives an indication. It is desired that specifications is assuming that displays and lamps of operation panels are used under lighting of 300 lux or brighter.

Viewability of displays in a bright room is associated with countermeasures to glare and performance in brightness and contrast of displays.

(2) Dimmer control

It is desired that illuminance of examination rooms is adjustable to obtain optimum illuminance with taking viewability of screens and adequate brightness into consideration.

(3) Countermeasures to glare

It is necessary to confirm whether glare occurs on displays and to take countermeasures to the glare.

- Adjust the position and angle of display and improve lighting equipment to prevent reflected glare (reflection of light to a display including lighting of the room).

- Improve light shielding of windows and adjust layout of the room to prevent direct glare (bothersome light directly entering into the eye).

Provision of lighting equipment, that has taken countermeasures against glare, including louver (a cover for lighting equipment) lighting and indirect lighting, is especially important for ultrasonography because the position of displays is properly adjusted depending on the contents of examination and a range of sonographer's gaze direction is wide.

(4) Lighting of examination rooms that use CRT displays

Screens of CRT displays (cathode-ray tube displays) may have poor viewability in a too bright room. When an ultrasonic diagnostic equipment with a CRT display is used, it is desired to provide especially elaborate countermeasures to glare and adjust brightness and contrast of a scene, and then to make the room brighter within the range that the screen is clearly visible.

Table 3-5. Outline of Recommendations regarding lighting

Item	Target of countermeasures	Outline
(1) Securement of illuminance	Lighting equipment	Adjust the room illuminance so that brightness of display and surrounding brightness are approximately equal. It is desired that specifications is assuming that displays and lamps of operation panels are used under lighting of 300 lux or brighter.
(2) Adjustment of illuminance	Lighting equipment (dimming)	Equip illuminance adjustable installation for every examination room.
(3) Countermeasures to glare	Lighting equipment and methods, the position and angle of a display, window drapes and the layout of surrounding things that interrupt lighting	Implement countermeasures to glare. Countermeasures to lighting equipment are desired.
(4) Countermeasures to CRT displays	Regulatory function of displays Lighting equipment and methods, the position and angle of a display, window drapes and the layout of surrounding things that interrupt lighting	Confirm viewability of images and provide elaborate countermeasures to glare, and then to make the room brighter within the possible range.

Table 3-6. Reference value of illuminance of the light in examination room

Contents of the ultrasound images	Approximate ALL	Liquid crystal displays with maximum luminance of 100cd/m2		Liquid crystal displays with maximum luminance of 200cd/m2	
		Appropriate illuminance(lux)	Range (lux)	Appropriate illuminance (lux)	Range (lux)
Very dark abdomen image	1%	8	3～24	16	5～50
An abdomen image with the average brightness	5%	40	13～120	80	30～240
Relatively bright image including charts etc.	10%	80	30～240	160	50～500
Image with charts or documents with high contrast		300 lux or brighter		300 lux or brighter	

Appropriate illuminance: Horizontal illuminance of the ceiling light that makes luminance of wall and display equal.

Range: The range of horizontal illuminance that makes the difference in brightness of wall and display less than 3 times.
Reflectance of the wall is assume to be 0.8, Incident light angle is assume to be 60 degree.

ALL(Averaged luminance level) : An index for the brightness of the displayed image. The percentages of spatially averaged luminance across the whole image to the maximum brightness (luminance of the brightest white) of the display.

Maximum luminance of 100cd/m2: Seen in the cases of ultrasound equipment.

Maximum luminance of 200cd/m2: Seen in the cases of computer display..

3.4.1.3 Air conditioning and ventilation of examination rooms

It is desired that air-conditioning of individual rooms is adjustable in an optimal way because adjustment of room temperature may be required depending on dressing, physical condition, and request of sonographers. It is desired to pay attention to ventilation in examination rooms that often are demarcated space without windows. Standards regarding ventilation include Chapter 2, Ordinance on Health Standards in the Office (Articles 2 to 12) "Environmental Management in the Office"[16] that regulate comfortable conditions in business offices; it is desired adhere to these standards.

3.4.2 Ultrasonic diagnostic equipment

Specifications for ultrasonic diagnostic equipment to achieve ideal less-straining postures described in a section 3.1 are shown below. In addition, effectiveness of adjustment of the position and the height of operation panels and displays are affected by adjustable range of the position and the height of examination tables and chairs; therefore, it is necessary to conduct countermeasures so that appropriate working postures are obtained in a combination with related equipment, such as examination tables and chairs, as indicated in the next section. Dimensions of equipment and adjustable ranges are shown in Table 3-6. The height of operation panels and displays indicated here are set on the assumption that the height of examination tables and chairs are appropriately adjustable. In addition, followings are described on the assumption that the probe is held with the right hand, and equipment is operated with the left hand unless otherwise noted.

Table 3-6. Recommendations regarding dimensions of equipment and adjustable ranges

		Posture of sonographers	Recommendations	Remarks
Main unit	Depth		A depth behind the display is short.	
	Width		The right and left ends of the operation panel are movable to the end of the main unit or outer.	
Operation panel	Depth		300 mm or less	Adjust so that operation targets stay within a working area.
	Width		300 mm or less	Adjust so that operation targets stay within a working area. As the next best measure, adjust so that the operation targets stay within a range of 300 mm.
	Height	Sitting position	580 - 750 mm	An adjustable range of when the height of examination tables is adjustable within a range of 300 - 570 mm. As the next best measure, adjust so that an adjustable range of a height difference between an examination table and operation panel becomes appropriate range (170 - 270 mm) when the examination table is too high and a high chair with a footrest is used.
		Standing position	930 - 1140 mm	
	Right and left position		At least, the end of the panel is movable until touching with the end of the examination table.	Adjust so that operation targets stay within a working area.
	Back and forth position		Operation panel can be drawn closer to a position that operation targets stay within a working area in various postures of sonographers.	It is desired that angle is also adjustable.
Display	Height	Sitting position	1090 - 1330 mm	When the height of examination table is adjustable within a range of 300 - 570 mm.
		Standing position	1420 - 1720 mm	
	Position		Movable to the end or top of an examination table	
	Angle		Rotatable at least 30 degrees (horizontal). Elevation adjustable.	

3.4.2.1 Main unit of ultrasonic diagnostic equipment

It is required that movement of the main unit of ultrasonic diagnostic equipment and locking procedure are easy and less straining. It is desired to move the main unit easily and quickly as much as possible. It is desired to reduce size and weight of the ultrasonic diagnostic equipment to eliminate limitation of layout. Recommendations are described below. The outline of the recommendations is shown in Table 3-7.

(1) Ease of move and position adjustment of the main unit

It is necessary that ultrasonic diagnostic equipment can be moved easily with small strength of one

person by attaching casters and handles to the main unit because it is necessary to adjust the position of the main unit frequently according to the region examined, examination methods, and physique of examinees. It is necessary that locking manipulation is also easy. It is desired that these manipulations can be conducted without changing a sitting position during examination. It is especially necessary that the position of the main unit is easily adjustable when move of the main unit is required to bring the operation panel closer to appropriate position (within a working area) nearby the sonographer.

(2) Downsizing

It is desired that the width and depth of the main unit would be designed compactly in consideration of stability (tipping angle) and safety of transportation to adjust position of equipment and the angle against examination table even in a space of small examination room.

It is desired that the width of the main unit is less than that of operation panel and display because ultrasonic diagnostic equipment is placed alongside of the examination table (bed), and the position of an operation panel and display is often adjusted to a position right or left of the main unit (Figure 3-3).

It is desired that a depth of the main unit is small to realize an optimum layout when adjustment to the most appropriate back and forth position needs to be conducted by movement of ultrasonic diagnostic equipment (Figure 3-2). This is necessary when ultrasonic diagnostic equipment is used in a small room or when the position of examination tables cannot be moved readily. Operation panels and displays may be placed in a position of the upmost part of an examination table (cranial side of examinees) in neck examinations. In such cases, more space behind the ultrasonic diagnostic equipment is required if a depth of the ultrasonic diagnostic equipment is longer. It is ideal to shorten the depth until the back surface of a display adjusted to appropriate distance from an sonographer because there is no limitation of layout when the ultrasonic diagnostic equipment is used in a narrow room.

(3) Space to place the feet is secured

A space to place the knee and legs under the operation panel is needed to form a natural working posture.

(4) Layout that accessories, etc. are arranged within sonographer's reach

It is necessary that holders of a probe and ultrasound gel, which are frequently used during examination, are placed in a position that does not interfere with examination within the working area, and can be easily reached without changing the posture for examination.

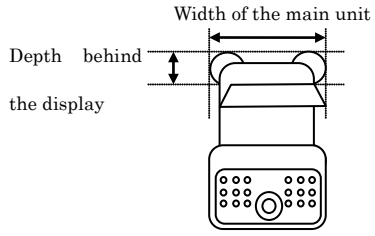


Figure 3-3. Size of main unit

Table 3-7. Outline of recommendations on main unit of ultrasonic diagnostic equipment

Item	Outline
(1) Ease of move and position adjustment of the main unit	Ultrasonic diagnostic equipment can be moved easily with small strength of one person by attaching casters and handles to the main unit. Locking operation is also easy.
(2) Downsizing	- It is desired that the width and depth of the main unit would be designed compactly in consideration of stability (tipping angle) and safety of transportation. - It is desired that the width of the main unit is less than that of operation panels and displays. - It is desired that a depth of the main unit is small to realize an optimum layout when adjustment to the most appropriate back and forth position needs to be conducted by movement of ultrasonic diagnostic equipment.
(3) Space to place feet	Securement of a space below the operation panel to place the knee and feet.
(4) Layout that accessories, etc. are arranged within sonographer's reach	Holders of a probe and ultrasound gel, which are frequently used during examination, should be placed in a position that does not interfere with examination within the working area, and can be easily reached without changing the posture for examination.

3.4.2.2 Operation panels

It is ideal that all operation of the panel with holding a probe can be done within a working are of one hand, and with bending the elbow into about 90 degree without elevating the arm (elbow height rule, Figure 3-1). To achieve this, it is desired that the top surface of the panel can be adjusted to a height of the elbow with height adjustment, that the panel can move closer to hand, and that the size of the area for the panel operation stays in a working are of one hand. It is desired that the position of an operation panel is adjustable over a wide range as much as possible without moving a heavy main unit. If a probe holder, etc. is space consuming, it should also be considered.

The height of operation panels indicated here are set on the assumption that the posture is an ideal posture, that the feet of sonographers stably touch on the floor through adjustment of the height of an examination table and chair.

The foundation of ideal size and position of operation panels are described below. It is ideal that operation panels can be moved to working area at hand in various postures such that sonographers lean the upper body or sit on an examination table; therefore, it is desired that the panels are compact.

There are data that a depth of a regular working area that can operate without elevating the upper arm is 390 mm (Figure 2-1). The forearm length of small females is about 30 cm. Considering, however, that they can stretch the arm forward about 100 mm more by 20º bending of the upper arm or 20º bending of the upper body, the depth becomes about 400 mm forward.

When an operation panel comes closer to a distance of 90 mm from the front of the abdomen of the body trunk, the elbow needs to be drawn backward to behind of the back of the body trunk depending on the size of the body (the elbow contacts with a backrest of the chair); therefore, if a space between the operation panel and the body trunk of the sonographer is drawn to at shortest 100 mm, a depth of operation panel that stays within a forward depth of 400 mm would be 300 mm or less.

Regarding a right and left width of operation panel, sonographers cannot bring the panels to front of them when examination is conducted with facing to the examinee; as a result, an operation panel will be placed at a side of a hand that does not hold a probe (the left hand in most cases). In such cases, flexible arrangement would be possible if the width of the panel remains within the working area although the direction of the operation panel is different depending on a movable region and rotatable region of the panel and a way that the main unit is placed. Accordingly, it is considered that it is ideal that a depth of operation panels is 300 mm and less and a width is about 300 mm and less, and that the panel can be brought closer to hand using an arm with a wide movable range or with casters that can move the panel independent from the main unit and does not hinder a legroom, so that height and direction of the panel are freely adjustable (Figure 3-4). Recommendations are described below. The outline of the recommendations is shown in Table 3-8.

(1) Thinness

A space below an operation panel to put the knee and feet are necessary for natural working postures. It is desired that an operation panel is thinner to secure the space for the feet.

(2) Mobility that is independent from a display

Ideally, the operation panel and display shall be adjustable independently each other. It is preferred that displays are adjustable to an appropriate distance in front of sonographers, and that distance and angle are independently and properly adjustable as countermeasures for glare. On the other hand, it is desired that operation panel can be brought closer to hand according to various postures including inclination of the upper body of sonographers

(3) Dimensions of operation panels

In view of the fact that operation targets such as buttons and knobs are stay in a working area of the arm in various postures of sonographers, and that the panel does not contact with examinees etc. even if the position of the panel is changed in a wide range, it is desired that the size of operation panels is downsized. It is desired that the operation targets stay within a range of 300 mm of the near side of the operation panel. It is ideal that a width is within 300 mm; however, the range may be larger if the operation targets can stay within a working range of one hand by position adjustment of equipment and concentration of operation targets into the working range. When a width of the panel is large, it is desired that the operation targets are concentrated within a range of 300 mm of the side of sonographers who take various posture including inclining the upper body. In such cases, it is desired that these adjustment can also correspond to a situation

that the positional relationship of sonographer and equipment is inverted.

(4) Height of operation panels

Desirable adjustable ranges for the height of operation panels are shown below. Meanwhile, adjustable ranges for the height in a sitting position on a chair indicated here are set on the assumption that the height of examination tables is appropriately adjustable.

- Sitting position on chairs: 580 - 750 mm (when the height of examination tables can be adjusted within a range 300 - 570 mm: covers 90% of both male and female Japanese)
- Standing position: 930 - 1140 mm (covers 90% of both male and female Japanese)

It is desired that the operation panel is adjustable to the height that allows operating the panel in a posture with bending the elbow into 90 degrees without elevating sonographer's arm (elbow height rule). (Adjustable range that when the height of examination tables can be appropriately adjusted, that sonographers are in a sitting position on a chair, and that covers 90% of both male and female Japanese: 580 - 750 mm; popliteal space height in a sitting position + olecranon height in a sitting position)

When the height of an examination table is not adjustable and is too high, it is necessary to adjust chairs higher and to secure a stability of the feet using a footrest as the next best measure. In such cases, it is desired to set an adjustable range of the operation panel corresponding to the height of the examination table, and the operation panel is adjustable within the range of 170 - 270 mm, which is a height from the top surface of an examination table to the top surface of the operation panel (see a section of "3.4.3 Examination tables", Table 3-7).

The values of the operation panel height that covers 90% of both males and females becomes 930 - 1140 mm (olecranon height in a sitting position + 20 mm) when the panels are operated in a standing position. If stretching of the forearm from horizontal to 20 degrees (the angle of the elbow becomes 110 degrees) to operate a low operation panel in a standing position is allowed, this value covers 95 percentile of males if the height can be up to 930 mm. To deal with crouching postures, elevation of the arm in small females (5 percentile) can be 90º (the upper arm becomes horizontal) when the height was lowered to 580 mm; however, still the elevation cannot be avoided. Therefore, it is desired to make the height lower. To avoid this, it is desired to examine improvement of methods to place examinees in a high position safely and examination methods to avoid this for a crouching posture.

(5) Right and left position of operation panels

It is desired that the end of operation panels can be moved to the end of the examination table.

It is desired that movability of operation panels is determined in consideration that operation targets can stay within a working area with handling a probe. In examinations of the abdomen, neck, lower extremity, and breast conducted to examinees in supine position by sonographer in a sitting position on a chair, it is

necessary that at least the end of an operation panel can move to a position of the end of an examination table (Figure 3-5). When sonographers lean the upper body toward examinees and when an sonographer sits on a bed, it is desired to arrange so that the operation targets stay within the working area. If the movable range was not enough to handle the conditions, it is desired to concentrate functions to be operated to the sonographer's side so that the operation targets stay within the working area. In such cases, it is desired that these adjustment can also correspond to a situation that the positional relationship of sonographer and equipment is inverted. It is desired that move of the main unit is easier on the assumption that position adjustment of operation panels is done by move of the main unit.

(6) Back and forth position and rotation of operation panels

It is desired that back and forth position of operation panel can be drawn closer to a position (within an area 400 mm forward) that all manipulation can be conducted within a working area of the left hand of the sonographer in a position applying a probe (Figure 3-4). It is also effective to arrange so that operation targets stay within the working area by allowing an operation panel rotatable.

(7) Ease adjustment of the position of operation panels

It is desired that sonographers can adjust the operation panel position easily and quickly in one hand. It is necessary that move of main unit is easy if a response by moving the main unit is assumed.

(8) Support for the wrist to forearm

In manipulation of trackball and operations that is conducted continuously or repeatedly without changing the position of the arm, it is desired to support the wrist or the forearm the near side of the panel. A status that has no wrist bending and no strain on fingers is desired. It is desired to consider stability and amenity of the surface of the support of the wrist and the arm (shape, angle, no corner or projection, a rubber part that contact with the arm, etc). It is desired that the support the near side of the panel would be easily accessed to put and rest the wrist or arm.

Methods to operate buttons concentrated within a fingers' reach that allows operation with supporting the wrist or upper arm without moving the upper arm is effective to reduce strains. If the shape and layout of knobs and switches are designed properly, it is expected that smooth and quick operation become possible through becoming skillful of the operation. On the other hand, the concentrated buttons may become complicated for people who are not familiar with operation of such equipment.

(9) Integration of operation methods

It is desired to employ specifications that give consideration to usability are integrated among products and manufacturers, for example, regarding relationship between equipment and actions including the position of buttons and knobs of operation panel, directions of manipulation (to which direction a knob is turned and a switch is turned up or down).

(10) Operation of other than operation panel

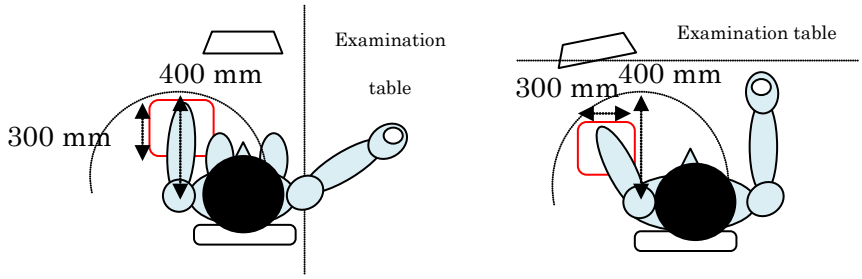
It is desired that to arrange a touch panel, switches, and holders, which are frequently used and manipulated without holding a probe, in a place that does not cause elevation of the arm and within a range short on reach.

(11) Response to bright rooms

It is desired to design displays so that lamps to display information are adaptable to a bright room of 300 lux or brighter on the assumption that specifications for displays correspond to room of 300 lux or brighter.

(12) Application of technologies that eliminate other limitation of the left arm

It is effective to eliminate a limitation of the left arm posture during frequently conducted operation by employing a remote control (near the left hand, or on a probe) and voice-recognition technology, or to avoid using the left hand. It is considered that this is especially necessary in examination of the lower extremity conducted to examinee in a sitting position or standing position. It is desired that foot pedals can be used as a remote control, especially as an option in case of both hands need to be used.



A. When an examinee is in a supine position B. When an examinee is in a face-to-face position

Figure 3-4. The range of operation targets on the operation panel within the work area of the left hand

Table 3-8. Outline of recommendations on operation panels

Item	Outline
(1) Thickness	- A thinness that can secure a space for feet.
(2) Mobility	- The position of operation panels is adjustable independent from a display.
(3) Dimensions	- Downsizing (ideally, right and left width of 300 mm and less, and depth of 300 mm and less) - Concentrate operation targets to an sonographers' side (to a near side, a side that the upper body is inclined)
(4) Height	- Adjustable to a height so that sonographers can operate the panel in a working posture (a sitting position on a chair or standing position) with bending the elbow at angle of about 90º. - Adjustable range in a sitting position on a chair: 580 - 750 mm (When the height of an examination table is adjustable within a range of 300 - 570 mm) - When the height of an examination table is too high in a sitting position on a chair, and chair is adjusted higher and a footrest is used as the next best measures: Adjustable range of a height from the top surface of an examination table to the top surface of a display: 170 - 270 mm - Adjustable range in a standing position: 930 - 1140 mm
(5) Right and left position	- When sonographers are in a posture for examination, operation panel can move to the position so that operation targets stay within a working area. - At least the end of operation panel can move to the end of examination table.
(6) Back and forth position and rotation	- All operation targets remain within a working are of the sonographer's arm that operate a panel in a posture applying a probe by adjusting back and forth position and rotation.
(7) Ease of adjustment	- Sonographers can adjust the operation panel position easily and quickly in one hand.
(8) Operation targets other than operation panel	- Arrange a touch panel, switches, and holders, which are frequently used, in a place that does not cause elevation of the arm.
(9) Response to bright rooms	- Specification shall be set so that lamps for information display can be used even in bright rooms of 300 lux or brighter.
(10) Technologies that eliminate the limitation of the left arm	- Adoption of remote control (beside the left hand, or on a probe) or voice-recognition technology.

3.4.2.3 Displays that are easily adjustable the image quality, a broad range of position, height, and angle

It is ideal that displays are placed in front of sonographers so that sonographers can look at the display in slightly downward gaze without rotating the neck. It is desired that a movable range is set so that displays are adjusted in an ideal position.

There are many problems of posture in current cardiac examination that sonographers lean over examinees and stretch an arm, examination of organs in the left side abdomen, and examination of the lower extremities that conducted in a crouching posture, and the limitation of display position is also one of reasons for the problem. Development of main unit that can be flexibly placed in a position different from traditional place and independent display equipment is desired.

To correspond to a narrow examination room, it is desired that the position of display is adjustable in an optimal way so that main unit of ultrasonic diagnostic equipment is located next to an examination table (Figure 3-5). It is desired that the position of display can be adjusted in a wide range as much as possible without moving the heavy main unit.

The height of displays indicated here assumed an ideal posture that the height of examination tables and chairs are adjustable and that sonographer's feet stably touch on the floor. Recommendations on displays are described below. The outline of recommendations is shown in Table 3-9.

(1) Adoption of thin, light liquid crystal displays, etc. that are very less effect of glare

Spread of the latest display equipment including liquid crystal displays that are thin and light, are easily position adjustable, and can reduce glare instead of CRT displays is desired. Displays with performances including sufficiently high resolution and fast response speed are desired.

(2) Displays that are adjustable so that a screen is easily viewable even in a bright room

It is desired that brightness and contrast of displays are adjustable according to conditions including lighting of the examination room. In the current situation, illuminance of examination room is set at few to few-tens lux in many cases because ultrasound images have low brightness. In the cases that dimmer control is not available, eye-strain is not avoidable. It is desired that displays is adjustable so that a screen become clearly viewable in brighter room. To make examination-rooms brighter, brightness and contrast performance of displays should be improved and dimmer control is necessary for ultrasound examination rooms.

(3) Height adjustable displays

It is necessary that the height of displays is adjustable so that working postures become appropriate. If the height of examination table can be adjusted appropriately, an adjustable range of display height, that assumed examination conducted by sonographers in a sitting position, is 1090 - 1330 mm (the height from

the floor to the top end of displays).

In examinations conducted by sonographers in a sitting position, adjust displays to a height best for a sitting position (When displays are height adjustable, a total of adjustable range that covers 90% of both male and female Japanese, popliteal space height in a sitting position, inner canthus height in a sitting position, and 20 mm of footwear thickness: the height to the top end of displays 1090 - 1330 mm; and a range that covers 80% of them: 1110 - 1310 mm).

(4) Displays adjustable to a height of the face in a standing position

An adjustable range of displays that required adjusting the displays in front of sonographers in a standing position is 1420 - 1720 mm (a height from the floor to the top end of the display).

When operation in a standing position is assumed, it is necessary to make displays adjustable to a height of the eyes in a standing position. A method that a display can be adjusted to almost the front of the eyes in a standing position is better than a method that the display is looked in downward gaze with a large upward angle. In such a case, an adjustable range of a height to the top end of displays that covers 90% of both male and female Japanese is 1420 - 1720 mm (as a thickness of footwear, 20 mm was added to the height of the inner canthus in a standing position), and the lower limit of the range that covers 80% of males and females is 1430 mm. When a lean of the neck up to 25º (downward gaze) is allowed, the upper limit of the adjustable range is 1700 mm when a distance between the display and the eyes is defined as 400 mm. However, the display needs to be leaned upward.

(5) Displays with a height corresponding to a crouching posture for lower extremity examination

To correspond to a crouching posture, displays need to be adjustable to as low as 700 mm from the floor.

It is ideal to develop methods to place examinees in a high position safely because strains caused by a forward-bent posture and a crouching posture become larger when sonographers examine lower region of the examinees. When such measures are not available, improvement of examination methods and response such as reduction of working hours are desired. When a display needs to be adjusted to a height so that sonographers can look at the display without looking up in a crouching posture, it is effective to make displays (the center, or ideally the top end of the display) adjustable to a position as low as 700 mm from the floor (as a thickness of footwear, 20 mm was added to 5 percentile value of the height of the eyes in female in a crouching posture) to respond to 90% of people including small females.

(6) Displays that are right and left position and angle adjustable

It is necessary to make right and left position and angle of displays adjustable to reduce a rotation of the neck to watch the display. For examinations of the abdomen, heart, breast, and neck, it is desired that the position of displays is adjustable so that at least the right end of the display comes to the left end of an examination table. Therefore, it is necessary that the right end of the display can move to at least the rightmost end of the main unit of ultrasonic diagnostic equipment (a position that the ultrasonic diagnostic

equipment and the right end and the lateral side of the examination table) (Figure 3-5). However, considering that the upper body of the sonographer inclines toward examinee in cardiac examinations that sonographers sit on the end of an examination table, it is desired that displays can move to right position.

It is desired that displays can turn up to about 30º to the left corresponding to a situation that an sonographer sits on the end of an examination table at an angle.

In examinations of the lower extremities that are conducted with an sonographer and examinee facing each other, it is considered as the best way to move equipment and examinee closer each other and to place both of them in front of the sonographer. When the examinee sits on an examination table (bed) and examination is conducted according to a standard equipment layout that place ultrasonic diagnostic equipment alongside of the examination table, a great rotation of the neck occurs. To improve this, it is effective to allow the display turning until it become almost parallel with the side of the examination table, and moving to the almost front of the sonographer (the end of the examination table) (Figure 3-4B).

When the sonographer leans over on the examinee in examination of the organs locating in the left side of the abdomen, the inclination angle of the upper body to the right become 25º or more in small females. In this case, the center of the sonographer locates almost at directly above the end of the examination table. To prevent a rotation of the sonographer's neck in such a case, it is necessary that a right half of 19-inch display locate more to the right than the end of the examination table. In this respect, a posture leaning the upper body toward the side is already problematic; therefore, it is desired to give consideration to fundamental improvement of examination methods.

(7) Distance between a display and sonographers' eyes

It is necessary that displays are distance adjustable more than a range of a distance between a display and sonographers' eye so that the visual angle becomes 30 - 45º in a possible various working postures (Figure 3-6).

(8) Ease of adjustment of the position, height, and angle of displays

It is desired that adjustment of the position, height, and angle of a display can be done easily and quickly in one hand without changing the sonographer's working posture for examination.

(9) Visibility of displayed contents

Regarding images and text information displayed on displays using software, it is needed to give consideration of visibility that does not become strains on sonographers in a possible various position of the displays.

Table 3-9. Outline of recommendations on displays

Item	Outline
(1) Adoption of thin, light liquid crystal displays, etc.	- The latest display equipment including liquid crystal displays that are easily position adjustable, can reduce glare, and have high performance.
(2) Adjustable so that a screen is easily viewable even in a bright room	- Adjustable to illuminance of 300 lux or brighter in consideration of eyestrains. - A screen is readily adjustable.
(3) Height adjustable	- Adjustable to optimum height for a sitting position for examination tasks on a chair. Adjustable range of a height from the floor to the top of a display: 1090 - 1330 mm (when the examination table is height adjustable)
(4) Adjustable to a height of the face in a standing position	- Adjustable to optimum height for a standing position for examination tasks. Adjustable range of a height to the top of a display: 1420 - 1720 mm
(5) Adjustable to a height corresponding to a crouching posture for lower extremity examination	- Adjustable to a low position corresponding to a crouching posture. (Adjustable to as low as 700 mm)
(6) Right and left position and angle adjustable	- Right and left position and angle of displays are adjustable to reduce a rotation of the neck. - For examinations of the abdomen, heart, breast, and neck, the position of displays is adjustable so that at least the right end of the display comes to the left end of an examination table. - Displays can turn to the left corresponding to a situation that an sonographer sits on the end of an examination table at an angle.
(7) Distance between a display and sonographers' eyes	- Distance adjustable in a suitable range of a distance between a display and sonographers' eye in a possible various working postures.
(8) Ease of adjustment of the position, height, and angle	- Adjustment of the position, height, and angle of displays can be done easily and quickly in one hand without changing the working posture.
(9) Visibility of displayed contents	- Regarding displayed images and text information, displays have a visibility that does not become strains on sonographers in a possible various position of the displays.

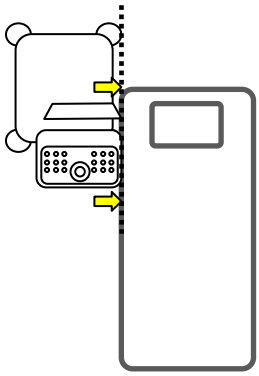


Figure 3-5. A minimum required adjustment range to the right side for position of a display and operation panel (examination when an examinee is in a supine position)

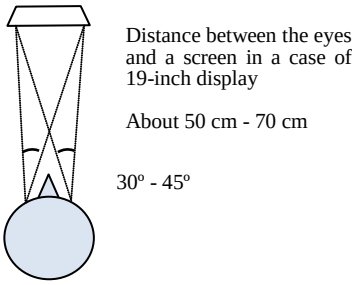


Figure 3-6. A visual angle of display

3.4.2.4 Probes

There are various examination methods and the size of sonographers' hands varies; therefore, it is desired that the size and shape of grips of probe are selectable.

It is desired to design probe cables so that the cable can be placed without hindering the operation and without touching examinees. Carrying the cable on the shoulder is also a straining factor [17]. There are a great number of opinions that the cable hinders examinations in the present circumstances. Therefore, it is effective to devise weight reduction of cables or placement without hindering, and to introduce cordless probes in the future. Recommendations on probes are described below. The outline of recommendations is shown in Table 3-10.

(1) It is desired that the shape of probes and the thickness and shape of grips are selectable according to examination methods and the size of sonographers' hands. It is also effective to make a grip part changeable or deformable.

(2) When strength is applied, it is effective to use relatively thick grips that can be held with a power grip (a gripping way of hammer) for prevention of musculoskeletal disorders. On the other hand, thinner grips are suitable when the grip is pinched with weak force for precise position adjustment. It is desired to develop and study on grips suitable for various operation tasks of sonographers, for example, the shape of grips that assumed flexible handgrips

(3) Lighter probes are desired.

(4) Softer and lighter cables are desired.

(5) It is desired to place a hanger, etc. to avoid getting a cable on the examinee's body in consideration to the position that does not hinder the operation. It is also effective to lead cables from a position that does not hinder the operation, and to place connectors at the position so that the cables can be shorter and lighter (from under the examination table, above the head, etc).

(6) It is desired to reduce complexity and improve posture and strength required during connection and disconnection when frequent connection and disconnection of connectors are assumed.

(8) Introduction of cordless probes is effective.

Table 3-10. Outline of recommendations on probes

Item	Description
(1) Thickness and shape	- Selectable probes according to examination methods and the size of sonographers' hands. - Development and research of optimum grips.
(3) Weight	Lighter probes are desired.
(4) Material and weight of cables	Soft and light.
(5) Measures for cables including a hanger	- Placement of cables in consideration of the position to avoid hindering the operation. - Improvement of the position of connectors and outlet of cables.
(6) Connector	Improvement of operability, postures, and required strength.
(8) Cordless probes	Introduction of cordless probes.

3.4.3 Examination tables

For optimization of postures for tasks conducted in a sitting position, it is ideal to use a height of chairs that can stably touch the soles of sonographers' feet on the floor as a standard. Therefore, it is desired that the height of ultrasonic diagnostic equipment (operation panels and display, respectively) and examination tables are adjustable to optimize working postures. Regarding horizontal movement of the position, if a chair for sonographers is freely movable with casters, it is necessary that a position of at least either ultrasonic diagnostic equipment or examination table can be moved and locked easily. Recommendations regarding examination tables are indicated below. The outline of the recommendations is shown in Table 3-11.

(1) Height of examination tables

It is desired that the height of examination tables is adjustable within a range of 300 - 570 mm (an adjustable range that covers 90% of both male and female Japanese of both sonographers and examinees), when examinees is in a supine position and sonographer examines in a sitting position.

In examinations conducted by an sonographer in a sitting position and that examinees lie down, it is desired that is an examination table is adjustable to a height that sonographers can examine with bending the elbow at angle of about 90º without elevating the upper arm holding a probe. (Figure 3-7, an adjustable range that covers 90% of both male and female Japanese of both sonographers and examinees: the height of examination tables: 300 - 570 mm; an adjustable range that covers 80% of sonographers: 310 - 560 mm)

(2) Height on the assumption that an sonographer sits on the examination table

When an sonographer sits on the end of an examination table and conducts cardiac examinations, it is desired that the examination table is adjustable to a height that allows sitting on it stably. Meanwhile, this condition (2) is met if the above (1) is fulfilled. (An adjustable range that covers 90% of both male and female Japanese: 370 - 460 mm; an adjustable range that covers 80% of them that is the same as a range of chair height described below: 380 - 450 mm) When the examination table is too high for the feet to touch on the floor as compared with the length of sonographer's lower legs, it is desired to place a footrest that can stably hold the feet.

In cardiac examinations that sonographers sit on an examination table, problems including a twist and inclination of the upper body, and elevation of the upper arm are still remaining. Fundamental improvement of examination methods and equipment is desired.

(3) The position of examination tables that can be moved and locked easily

When chairs can be freely moved with casters, it is necessary that a position of at least either ultrasonic diagnostic equipment or examination table can be moved easily. If move of the ultrasonic diagnostic equipment is not easy, it is necessary that an examination table can be moved easily and locked safely.

(4) Width of examination tables

If there is no risk of downfall for examinees and the examinee can pose and change their posture for examination easily, narrower examination tables (the width of regular examination tables is about 700 mm) can readily avoid increase of a distance between examinees and sonographers. When wide examination tables such as beds are used, it is especially important to ask examinees to lie down closer to the sonographer.

(5) Length of examination tables

Regarding the length of examination tables, when move of ultrasonic diagnostic equipment is not easy, and adjustment of the position of examinees to up and down (head and feet) directions is required, it is considered that it is desirable that examination tables have a length that allows adjustment of the position that examinees lie down is better than up and down adjustment of the position through move of examination tables on the premise of safety and amenity of examinees. Improvement based on development of equipment that can slide and adjust the position of examinees to up and down directions is ideal.

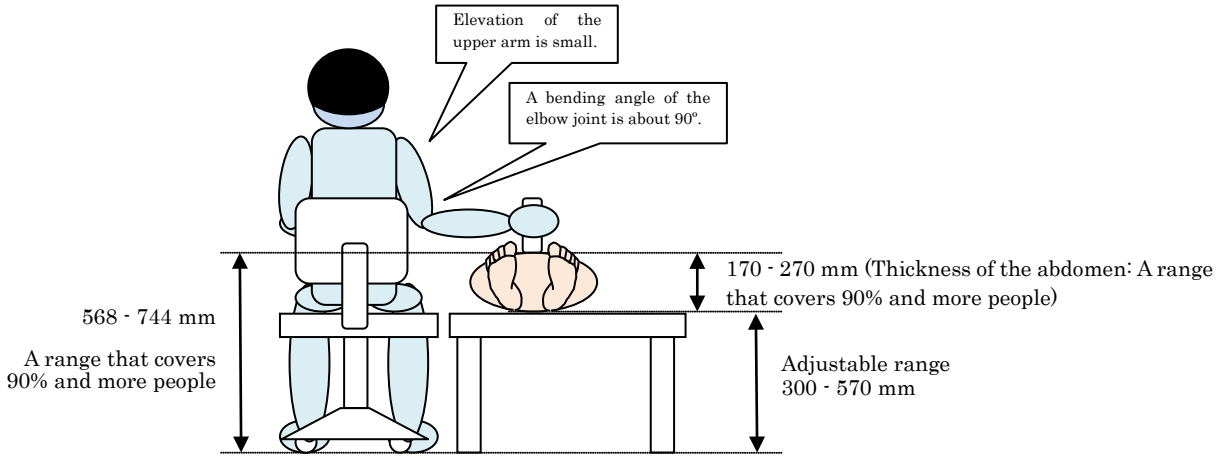


Figure 3-7. Adjustable range of examination table height when an sonographer is sitting on a chair and examines the abdomen of an examinee in a supine position

Table 3-11. Outline of recommendations on examination tables

Item	Outline
(1) Height	Adjustable to a height that sonographers can examine with bending the elbow at angle of about 90º without elevating the upper arm holding a probe. Ideal adjustable range of height: 300 - 570 mm
(2) Height on the assumption that an sonographer sits on the examination table	- Adjustable to optimum height for a sitting position of an sonographer. (it is adjustable if the above (1) is fulfilled) - In cardiac examinations that sonographers sit on an examination table, problems including a twist and inclination of the upper body and elevation of the upper arm are still remaining. Fundamental improvement of examination methods and equipment is desired.
(3) Move of the position and lock	Examination tables that can be moved easily and can be locked safely.
(4) Width	If there is no risk of downfall for examinees and the examinee can pose and change their posture for examination easily, narrower examination tables (the width of regular examination tables is about 700 mm) can readily avoid increase of a distance between examinees and sonographers.
(5) Length of examination tables	Length that allows up and down adjustment of the position that examinees lie down.

3.4.4 Chairs

It is necessary that chairs for sonographers can move easily with casters. It is necessary that examination tables are height adjustable to achieve ideal postures. When an examination tables is height adjustable, height adjustable chairs that can adjust according to the length of sonographers' lower legs are preferred. When the examination table is too high, it is necessary to adjust a chair higher and use a footrest.

Recommendations regarding chairs are indicated below. The outline of the recommendations is shown in Table 3-12.

(1) Chairs with casters

It is necessary to use casters that can move a chair moderately and smoothly. Casters that can be locked and released with easy handling are effective.

(2) Height of seating surface of chairs

It is necessary that the height of examination tables is adjustable to achieve ideal postures. If such adjustment is available, the height of the sitting surface of chairs needs only adjustment to a height that the soles of feet securely touch on the floor with bending the knees at a right angle. (An adjustable range that covers 90% of both male and female Japanese: 370 - 460 mm; an adjustable range that covers 80%: 380 - 450 mm)

(3) Equipment to avoid a crouching posture

In examination of the lower extremities that examine regions in a lower position of examinees, it is also effective to use chairs adjustable to lower position than the above-indicated range, or to use low platforms that is substitute for a chair and to be seated to avoid a crouching posture and forward-bent posture when the height of examination tables cannot be optimally adjusted.

(4) Backrest of chairs

It is effective to use chairs that are ergonomically considerate of a low back support as compared with chairs without backrest, and that form a good posture with the back straight by sitting back.

(5) Footrest of chairs

It is ideal to adjust a chair to a height that feet stably touch on the floor, and then adjust an examination table to a height accordingly. However, when the height of the examination table is not adjustable or too high, the next best measure would be to adjust a chair to enough height to avoid elevation of the arm holding a probe. In such cases, it is desired to use a footrest that can stably hold the feet.

Table 3-12. Outline of recommendations on chairs

Item	Outline
(1) Casters	Casters that can move a chair moderately and smoothly.
(2) Height of seating surface	Adjustment of chairs to a height that the soles of feet securely touch on the floor with bending the knees at a right angle on the assumption that the height of examination tables is optimally adjustable (an adjustable range that covers 90% of both male and female: 380 - 450 mm).
(3) Avoidance of a crouching posture	Use of chairs adjustable to lower position or low platforms that are substitute for a chair to be seated, and development of dedicated equipment.
(4) Backrest	Backrest that is ergonomically considerate of a low back support, and that forms a good posture with the back straight by sitting back.
(5) Footrest	When the height of the examination table is not adjustable or too high, the next best measure would be to adjust a chair to enough high to avoid elevation of the arm holding a probe and to use a footrest that can stably hold the feet in such cases.

3.5 Other efforts by facilities and related organizations to protect sonographers from musculoskeletal disorders

3.5.1 Dissemination and provision of information about problems to the parties concerned

The results of questionnaire to sonographers indicated that a rate of answers that they knew that ultrasonography tasks have risks of musculoskeletal disorders was 40%. Implementation of organized education by facilities, and information provision, education and enlightenment by manufacturers of ultrasonic diagnostic equipment and related equipment, and related organizations such as academic society, is desired.

3.5.2 Assessment of the situation of injury incidence and appropriate response by facilities

In the results of questionnaire to sonographers conducted by the Research and Development Team, a rate of answers that the facility can provide responses such as replacement or leave for treatment when musculoskeletal disorders occurred in sonographers was only 20%, answers that the facility cannot provide responses because of a manpower shortage, etc. was 30%, and answers of "do not know" was 46%. It is necessary to establish a system that managers of facilities assess the situation of injury incidence in sonographers and that can make an arrangement for reduction of workloads and treatment to prevent musculoskeletal disorders and to prevent exacerbation of disorders in sonographers who already have disorders.

4. Recommendations to work safely, comfortably and healthfully for sonographers

Ultrasonography is associated with unnatural and straining working posture for sonographers, and has great strain on the eye; therefore, it has a risk to cause low back pain, disorders of the arms, shoulders, and elbows, as well as the eyes by conducting repeated and prolonged examination many times on a routine basis. Several study reports describing that ultrasonography has risks of musculoskeletal disorders has been issued mainly from Europe and the United States. There is a research result in the United States indicated that symptoms occurred about 5 years after becoming engaged ultrasonography (Society of Diagnostic Medical Sonography, 2003 [9]). In this investigation of sonographer in Japan conducted by the Research and Development Team of the Japan Society of Ultrasonics in Medicine, it was indicated that a number of sonographer reported symptoms of musculoskeletal disorders and anxiety. Observation and analysis of working postures were also conducted in this investigation. As the results, several postures that have a risk of musculoskeletal disorders were demonstrated. These risky postures clarified in the study include a posture elevating the arm without a support, a posture that the upper body is leaning to one side or twisted, a forward-bent posture with a bent back, a posture that the neck is greatly leaned to a direction looking upward or rotated to right or left, a posture that the sole of feet are not touching on the floor, and a great bending of the wrist.

To prevent damages caused by ultrasonography, it is needed to contrive to develop environment of examination rooms and diagnostic devices, the layout of associated equipment, and working procedures to change the posture of sonographers more natural and less straining as much as possible. Because it is effective to reduce duration of risky posture, it is necessary to develop procedure to avoid continuous unnatural posture as much as possible, and to avoid working more than one hour continuously. It is also effective to contrive to change the posture as much as possible during a long-lasting operation. In addition, it is considered that acquiring of skills to examine in different postures when the same area is examined would be also effective to prevent musculoskeletal disorders.

It is recommended for sonographers to conduct items below as many as possible from feasible items.

Recommendations to work safely, comfortably and healthfully for sonographers

1. Frequently adjust the position of devises and equipment to avoid constrained posture

It is strongly recommended to frequently adjust the position of diagnostic devices, the position and height of a display and operation panel, the height of a chair, the position and height of an examining table so that sonographers can work in less-straining posture (Table 4-1).

2. Avoid continuous work for long time

Do not conduct examination tasks with handling a probe continuously and insert rest time or other tasks between them. Especially, tasks that continuously use a probe for more than one hour conducted on a routine basis should be avoided.

3. Ask examinees to change their posture

To conduct high-quality examination in less-straining posture, it is desired to frequently ask examinees to change their position and posture. In examinations of the abdomen, heart, breast and neck, and examinations in the supine position, it is desired to ask examinee on an examination table to move closer to sonographer (to a side of the table closer to the sonographer) as much as possible.

4. Take measures to glare by making the room brighter insofar as a display is easily viewable

It is desired to adjust the illuminance of light so that display is easily viewable. Adjust the illuminance to avoid the situation that the room is too dark and display is too bright and to avoid situation that room is too bright and surrounding brightness disturbs. Take measures including adjustment of the position and angle of the display, improvement of lighting equipment, and light shielding of windows to avoid reflected glare (reflection of light to a display including lighting of the room) and direct glare (bothersome light directly entering into the eye).

5. Improve posture and methods of working

It is desired to contrive working methods to avoid putting extra strength as much as possible. It is necessary to take care to improve and realize the working posture without stress through conscious consideration of posture of yourself as well as colleagues. It is also effective to consciously change the posture and to change examination method to insert changes and diversion of the posture to prevent work in the same posture continuously.

Workloads on sonographers should also be considered regarding selection of the body position of examinee and examination method. For example, selection to examine in the supine position should also be considered to avoid a great forward-bent posture, crouching posture, and rotation of the neck in examination of blood vessels of the lower extremity, according to circumstances. Meanwhile, when an sonographer conducts an examination face-to-face with an examinee, rotation of the neck and elevation of

the arm improve by putting equipment (a display and operation panel) in almost face-to-face position.

For the arm that holds a probe, it is important to minimize bending of the wrist and rotation (twist) of the arm.

6. Adjust displays readily viewable

It is desired to adjust brightness and contrast of displays to conditions readily viewable. In such case, it may be required to set equipment to optimize stored image data.

7. Stretching exercises

Stretching exercise during an interval of examinations is effective to prevent musculoskeletal disorders. If there is no time to implement a series of stretching exercises, it is also effective to be creative in order to conduct workable stretching exercises that can be done in a short time (Examples of stretching exercises: Figure 4-1).

8. Give extra consideration to risks other than ultrasonography

It is recommended to take consideration to tasks other than examination. Especially, transfer of examinees is high-risk tasks. When the sonographer implements a transfer, it should be conducted as a team that learned the right way, and transfer of examinees, who cannot stand up independently, alone should be avoided. It is effective to implement ergonomic improvement on chairs and desks, layout so that sonographers can conduct tasks other than ultrasonography, such as computer entry tasks in a good posture.

9. Make it a policy to maintain your health and physical strength

Because ultrasonography is a task to place a great physical workload, it is effective to make it a policy to maintain your health and physical strength in a good condition. Adequate rest and sleep are effective to prevent disorders and diseases including musculoskeletal disorders.

Table 4-1. A method to adjust the position of equipment in examination of the abdomen, heart, breast, neck, and lower extremities to examinee in the supine position on an examination table

1. Straighten the back naturally as much as possible and sit to assume a posture without leaning or twist of the upper body during operation of a probe. To that end, move manipulation parts of the equipment closer to the examinee on the examination table as much as possible.

2. Adjust the height of an examination table and chair to minimize elevation of the arm holding a probe and to assume a posture with bending the elbow at about 90º. The height of the chair is a desirable height that the soles of feet stably touch on the floor. However, if the examination table is not height adjustable, adjust the height of the chair and operation panel, and if the feet cannot touch on the floor, put the feet on a footrest.

3. Pull an operation panel nearer as much as possible so that the arm of the panel side does not need to be elevated or stretched, and adjust the height of the operation panel so that the sonographer can assume a posture with bending the elbow at about 90º. Arrange other things that need to reach during examinations within close reach and as near as possible in advance.

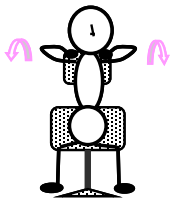
4. Adjust the position of a display to the front of an sonographer as much as possible so that the technician does not need to rotate the neck to right or left, and adjust the height of the display so that the top of the display comes to almost the front of the eyes.

Streching exercises workable between examination

Please conduct one or two of following stretching exercises between operations. This exercises become a break. By conducting them slowly in the order of following figures ([Relaxation of the shoulders 1] → [Relaxation of the shoulders 2]→[Stretching of the wrists]・・・), good blood circulation is promoted and results in reduction of a feeling of fatigue.

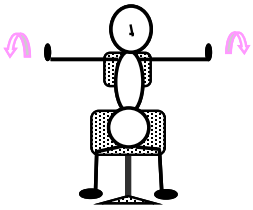
You do not have to do all exercises, but please select exercises that you can perform and continue easily, and conduct brief exercises frequently.

[Relaxation of the shoulders 1]



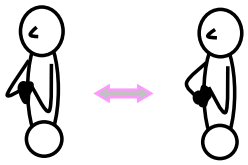
Put your hands on the shoulders, and rotate the arms with drawing a circle with the elbows.

[Relaxation of the shoulders 2]



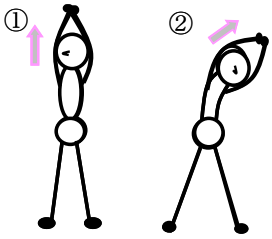
Stretch your arms sideways, and rotate the arms with drawing a circle with the hands.

[Stretching of the wrists]



Bend the elbows, and
(1) Push the back of the hand toward the palm side.
(2) Bend the wrist backward, and push the palm.

[Stretching of the side]



(1) Join hands together, and stretch up.
(2) Bend the body to the right and left slowly.

[Stretching of the chest]

Join hands together in your back. Stretch the elbows and throw the chest out.

[Stretching of the flank and back]

Twist your upper body slowly with pushing outside of a thigh with a hand of the opposite side you are twisting.

[Rotation of the ankles]

Rotate the ankles with touching your heels on the floor.

[Stretching of the back of thighs]

Stretch out one leg to the front, and incline the upper body forward bending at the root of the leg into L-shape.

★ Cautions ★

◎Don't stop your breathing. Breathe with a regular way and relax.
◎Slowly repeat the movement several times without generating momentum.
◎Be conscious of the part moving.
◎Feel the stretching muscle, and keep stretching for 10 to 20 seconds.
◎Don't push too hard when you feel a pain.

Figure 4-1. Examples of stretching exercises effective for sonographers (Developed by Masayo Yamamura, Tokyo Health Service Association)

5. Recommendations for managers of facilities conducting ultrasonography

It is necessary for managers of facilities to understand that examination tasks have risks of musculoskeletal disorders and to conduct countermeasures against the risks and to provide support for sonographers. It is necessary to develop environment, ultrasonic diagnostic equipment, and other equipment that sonographers can work efficiently and comfortably without demands for unnatural postures as much as possible. It is necessary to develop a system to understand actual status of occurrence of disorders, and to prepare and implement countermeasures against the occurrence of disorders.

It is strongly recommended that managers of facilities take the following countermeasures for prevention of disorders in sonographers. Hereinafter, recommendations that should be implemented as top-priority issue are described as "necessary to do". And, recommendations that should be implemented as much as possible are described as "desired to do", and recommendations that are not always required but effective as countermeasures are described as "effective".

Recommendations for managers of facilities

1. Development of ultrasonic diagnostic equipment and facilities, and environment of examination room for easy examination operation
2. Information for sonographer about risks of musculoskeletal injury and eyestrain, and implementation of prevention education
3. Development of management system for continuous working hours, working hours a day and development of working rotation
4. Implementation of preventive countermeasures against musculoskeletal disorders and eyestrain related to tasks other than ultrasonography
5. Development of a system to get a grasp of the status of injury occurrence, and implementation of appropriate response according to the status

5.1 Development of ultrasonic diagnostic equipment and facilities, and environment of examination room for easy examination operation

5.1.1 Development of equipment without risks of musculoskeletal disorders

It is desired that managers of facilities provide examination room environment, ultrasonic diagnostic equipment, and facility without injury risks for sonographers as much as possible in consideration of conditions described in a section "3.4 1Examination room, ultrasonic diagnostic equipment, and related

equipment to prevent musculoskeletal disorders and eyestrain".

5.1.2 Improvement measures in consideration of the current situation of working postures

Improvement measures for facilities in consideration of the current situation of working postures are described below. The outline of the measurements is shown in Table 5-1.

(1) Introduction of related equipment, including examination tables and chairs, that allows to conduct examination in a less-straining posture

In general, use of ultrasonic diagnostic equipment developed in consideration to movable range of displays and operation panels is effective to reduce strains to sonographers; however, it does not take advantage of the measures if chairs and examination tables are not appropriate. It is considered that it is especially important to introduce height adjustable examination tables. Specifications of ultrasonic diagnostic equipment of these recommendations described in a section "3.4 Examination room, ultrasonic diagnostic equipment, and related equipment to prevent musculoskeletal disorders and eyestrain" are premised on examination tables that are height adjustable within appropriate range. If the height of examination table is too high, higher chair is required as a next best measure. In such a case, a footrest is required, as well as the height of operation panel needs to be appropriately adjusted corresponding to the height of the examination table and chair. In addition, it is important to develop examination environment, including specifications of related equipment, without injury risks for sonographers. It is considered that many cases can be improved from the present circumstances through improvement of chairs (casters, height adjustment, and footrest) that requires relatively low cost and improvement of examination tables that cost less than that of main unit of ultrasonic diagnostic equipment.

(2) When the examination table is not height adjustable

In a sitting position, it is ideal to adjust the height of chair so that the soles of feet fully touch on the floor surface, and then adjust the height of other components (operation panel, examination table, display) in accordance with the chair. However, examination tables that are adjustable to sufficiently low height are not in widespread use at the present moment. When the examination table is too high, the arm holding a probe needs to be elevated if a chair is not adjusted higher. In such cases, it is desired to adjust the height of the sonographer's elbow by adjusting the height of the chair with a footrest, which can stably hold feet, higher to resolve the elevation of the arm, and to adjust the height of an operation panel to the height of the sonographer's elbow. It is desired that the footrest can stably hold both feet.

(3) Countermeasures for postures sitting on an examination table

In cardiac examinations, a posture that an sonographer sits on an examination table and applies a probe onto a region far from the sonographer causes a twist of the upper body and elevation of the arm. The twist of the upper body can be reduced to a certain degree by using an examination table with a projecting part to be seated. According to the results of the research, there is an example that brings a chair that is the same

height as an examination table into closer contact with the examination table, and sits on both the examination table and chair. Also, there are examples, in one case the sonographer uses a mattress that can be seated stably, and in the other a bed is converted for cardiac examinations in the facility to add a cut so that contact between a probe and cable is prevented. There are also methods to change the direction of a supine patient, and to operate a probe with the left hand (Table 2-2). It is effective to give consideration to these options. Meanwhile, a method that reduces a twist of the upper body with appropriate equipment and measures, and then the sonographer sits on the examination table may also be adaptable to examinations of regions other than the heart (for examination of far abdominal regions).

If an sonographer sits on an examination table and the table is too high as compared with the length of the sonographer's lower legs, the foot cannot touch on the floor stably. In such a case, it is desired to use a footrest that can stably support the feet.

(4) Adjustment of the position of operation panel

Adjustment to keep an operation panel within a work area to minimize the elevation of the upper arm can be done in a certain degree through position adjustment of main unit of ultrasonic diagnostic equipment, use of a movable range of operation panels, position adjustment of examination tables and examinees, and position adjustment of chairs. When the movable range of the operation panel is inadequate, it is desired to deal with the issue by adjusting the position of the ultrasonic diagnostic equipment or examination table into appropriate position as much possible, if the position of the ultrasonic diagnostic equipment or examination table is adjustable on the assumption that the chair is freely movable with casters.

(5) Frequent adjustment

It is desired to avoid unnatural postures as much as possible by applying functions to adjust the position of operation panels and displays and the position of ultrasonic diagnostic equipment with casters, and by frequently asking examinees to move their position.

(6) Countermeasures for a great anterior inclination of the upper body and a crouching posture in examination of the lower extremities

Examination that examinees sit on an examination table, and an sonographer takes a greatly forward tilting posture or a crouching posture causes great strains. Ideally, development of equipment to move examinees to higher position safely is desired. To deal with this issue, the workloads are smaller when examinees are examined in a supine position if possible. In our investigation results, there were examples that avoid taking a crouching posture and greatly forward tilting posture by sitting on a low platform (15 cm height) with casters.

(7) Multidimensional countermeasures

It is desired to implement possible countermeasures from various countermeasures indicated in a section "3. Countermeasures for musculoskeletal disorders and eyestrains in ultrasonography tasks" multi-dimensionally. It is desired to discover risks of musculoskeletal disorders in the equipment of the

facility, the body sizes of the sonographers and examination methods employed in the facility, and to conduct reduction of risks from feasible means. For examinations that are difficult to improve the posture, it is desired to contrive and implement feasible measures to reduce workloads as much as possible, and to take countermeasures including reduction of working hours or the number of examinations. Countermeasures related to working postures that are feasible depending on availability of height adjustment of existing equipment are shown in Table 5-2.

Table 5-1. Improvement measures for equipment implemented in facilities in consideration of the current situation of working postures

Item	Outline
(1) Introduction of related equipment, including examination tables and chairs, that allows to conduct examination in a less-straining posture	- Development of examination environment without risks of musculoskeletal disorders to sonographers including specifications of not only ultrasonic diagnostic equipment but also related equipment. - Equipment of especially height adjustable examination tables and chairs.
(2) When the examination table is not height adjustable	When an examination table is not the height adjustable and is too high, use a chair with a footrest that can stably support the feet and adjust the chair higher corresponding to the examination table, and then adjust the height of an operation panel to the height of the elbow of the sonographer, as a next best measure.
(3) Countermeasures for postures sitting on an examination table	- Reduction of a twist of the upper body by using an examination table with a projecting part to be seated. - Use a chair that is the same height as an examination table, and bring the chair into closer contact with the examination table. - Other devices of equipment that are feasible in the facility. - Use of footrest for when the examination table is too high as a seating surface.
(4) Adjustment of the position of operation panel	- Realize an appropriate layout through position adjustment of main unit of ultrasonic diagnostic equipment, use of a movable range of operation panels, position adjustment of examination tables, examinees, and chairs as much as possible.
(5) Frequent adjustment	Frequently implement adjustment of the position of operation panels and displays and the position of ultrasonic diagnostic equipment with casters, and transfer of the position of examinee to avoid unnatural postures as much as possible.

(6) Countermeasures for a great anterior inclination of the upper body and a crouching posture in examination of the lower extremities	- Ideally, development of equipment to move examinees to higher position safely is desired. - Examine examinees in a supine position if possible. - Take measures to avoid taking a crouching posture and greatly forward tilting posture by sitting on a low platform.
(7) Multidimensional countermeasures	Implement possible countermeasures from various countermeasures indicated in Section "3. Countermeasures for musculoskeletal disorders and eyestrains in ultrasonography tasks" multi-dimensionally.

Table 5-2. Countermeasures to working postures according to situations whether the height of equipment is adjustable or not

It is desired to adjust the position and angle of adjustable equipment including ultrasonic diagnostic equipment, chair, and examination table to the optimum conditions as much as possible in all cases.

Height of examination tables	Height of chairs	Height of operation panels	Possible countermeasures
○ Adjustable	○ Adjustable	○ Adjustable	• Adjustable to ideal height relationship
		× Not adjustable and too high	• Adjustment of the position and angle of an operation panel • Introduction of ultrasonic diagnostic equipment with a height adjustable operation panel
	× Not adjustable	○ Adjustable	• Introduction of a height adjustable chair (if feet are unstable, use a chair with a footrest)
		× Not adjustable and too high	• Adjustment of the position and angle of an operation panel • Introduction of a height adjustable chair (if feet are unstable, use a chair with a footrest) • Introduction of ultrasonic diagnostic equipment with a height adjustable operation panel
× Not adjustable and too high	○ Adjustable	○ Adjustable	• Adjust the height of a chair with a footrest higher • Introduction of a height adjustable examination table
		× Not adjustable and too high	• Adjustment of the position and angle of an operation panel • Adjust the height of a chair with a footrest higher • Introduction of a height adjustable examination table • Introduction of ultrasonic diagnostic equipment with a height adjustable operation panel
	× Not adjustable	○ Adjustable	• Introduction of a height adjustable chair with a footrest • Introduction of a height adjustable examination table
		× Not adjustable and too high	• Adjustment of the position and angle of an operation panel • Introduction of a height adjustable examination table • Introduction of a height adjustable chair with a footrest • Introduction of ultrasonic diagnostic equipment with a height adjustable operation panel

5.2 Information for sonographer about risks of musculoskeletal injury, and implementation of prevention education

It is necessary to inform sonographers that ultrasonography is a task that has a great physical workloads and risks of musculoskeletal disorders, and to educate knowledge and skills in consideration of both the quality of examination and health of sonographers. Shortening of examination time by improving skills, acquisition of working methods to avoid excess strength, acquisition of examination skills in many regions, and acquisition of examination techniques to avoid continuous examination of the same region in the same posture are directly or indirectly reduce risks of musculoskeletal disorders. Recommendations are described below. Recommendations are shown in Table 5-3.

(1) Dissemination of risks

It is necessary to disseminate risks of musculoskeletal disorders and countermeasures to people concerned.

(2) Use of a variety of working postures and examination methods

Because concentration of particular posture becomes a risk of musculoskeletal disorders, it is efficient that sonographers who work such examination environment learn a variety of examination methods. Here, a variety of examination methods include examinations of various regions and different examination techniques for the same region.

(3) Safety of transfer

It is necessary to disseminate about methods that are safe for both examinees and sonographers regarding transfer of examinees.

(4) Skills to implement high quality examination efficiently

Training and education for skills to implement high quality examination efficiently in a short time are also effective for prevention of musculoskeletal disorders.

Table 5-3. Information for sonographer about risks of musculoskeletal injury, and implementation of prevention education

Item	Outline
(1) Dissemination of risks	Dissemination of risks of musculoskeletal disorders and countermeasures to people concerned.
(2) Use of a variety of working postures and examination methods	Recommendations on use of a variety of examination methods and working postures.
(3) Safety of transfer	Dissemination of safe methods to transfer examinee.
(4) Skills to implement high quality examination efficiently	Training and education for skills to implement high quality examination efficiently in a short time.

5.3 Development of management system for working hours and working rotation

Prolonged or many times of implementation of highly straining examination is critical risk of musculoskeletal disorders. It is necessary to manage working hours and the number of examination based on the contents of recommendations described in "3.3 Measures for working hours".

5.4 Implementation of preventive countermeasures against musculoskeletal disorders related to tasks other than ultrasonography

It is necessary to pay attention to tasks other than ultrasonography. Transfer of examinee between a stretcher and examination table and between a wheelchair and examination table is high-risk task. Therefore, it should be managed so that such tasks are avoided as far as possible. Transfer of examinees, who cannot stand up independently, alone should be avoided. When the sonographer performs transfer, it is necessary to implement a transfer suitably after training of the right transferring method for operators and under the mentorship of healthcare staff that learned the right way. Use of appropriate equipment to reduce risks involved with transfer (such as a lift, sliding seat, etc.) is desired.

It is effective to implement ergonomic improvement as much as possible for tasks other than ultrasonography, such as computer entry tasks as well.

(1) It is necessary to develop procedures to avoid implementation of transfer as much as possible, or procedures and methods that can be safely conducted for both of examinees and sonographers.

(2) When sonographer implements a transfer, it is necessary to develop a procedure in which education about risks of transfer task and safe method is conducted, and then the task is conducted as a team that includes a person who can give appropriate directions.

5.5 Development of a system to get a grasp of the status of injury occurrence, and appropriate response

It is necessary to develop a system that can get a grasp of the status of injury of sonographers in the facility and can provide appropriate response to prevent musculoskeletal disorders as well as to prevent exacerbation of the disorders of sonographer who has disorders. Related recommendations are shown in Table 5-4.

Table 5-4. Development of a system to get a grasp of the status of injury occurrence, and appropriate response

Item	The contents of recommendation
(1) Understanding of the occurrence status	The occurrence status of musculoskeletal disorders needs to be understood. To that end, it is necessary to provide opportunities to report and consult about musculoskeletal disorders.
(2) Reinforcement of preventive measures	It is necessary to reinforce preventive measures indicated above 5.1 to 5.4 when musculoskeletal disorders are occurred.
(3) Reduction of the workloads of the persons who report symptoms	It is necessary to lighten the workloads of the persons who have musculoskeletal disorders and who report symptoms.
(4) Thoughtful consideration for treatment	It is necessary to make an arrangement to allow to receive required treatment and to take a leave of absence required.

6. Recommendations for manufacturers and technology developers of ultrasonic diagnostic equipment and related equipment

In design and development of equipment used for ultrasonography and related equipment should be designed to reduce risks of musculoskeletal disorders and eyestrains for sonographers described in a section "2. Risks of musculoskeletal disorders and eyestrain in ultrasonography tasks" on the assumption what kind of layout and methods testing are used for the operation in actual examination environment.

Ideal working posture for ultrasonography in a sitting position is realized when the feet stably touch on the floor, and the height of an examination table and ultrasonic diagnostic equipment is adjusted accordingly. Therefore, the spread of the height adjustable examination tables is important problem. Appropriate adjustment ranges of the height of the operation panel and display become different between when the height of examination table is appropriately adjustable and when it is required to adjust corresponding to an examination table that is not height adjustable which is spread in the present circumstances. The conditions described in section "3.4.2 Ultrasonic diagnostic equipment" are conditions that enable operation in an ideal posture using examination tables, which is height adjustable within an appropriate range.

There are some examples that unnatural postures is coerced as if such posture is standard and becomes common practice due to positional relationship among an operation panel, display, probe of ultrasonic diagnostic equipment, for example, in examinations of the heart, blood vessels of the lower extremity, and organs of the left side abdomen. It is desired that development of easier-to-use equipment that are free from existing designs and a system integrated ultrasonic diagnostic equipment with related equipment including an examination table. It is desired that manufacturers propose and educate usage directions of the ultrasonic diagnostic equipment that enables comfortable examination without injury risks.

6.1 Provision of equipment that have low workload on sonographers

It is ideal that products for ultrasonic diagnostic equipment that fulfill the conditions described in "3.4.2 Ultrasonic diagnostic equipment" are provided, and for related equipment, it is ideal that products that fulfill the conditions described in "3.4.3 Examination tables" and "3.4.4 Chairs" are provided.

Meanwhile, safety of equipment should be in accordance with the third edition of IEC 60601-1. It is necessary to consider tipping angles of the display and operation panel when movable ranges are increased. It is necessary to take consideration to safe and easily handled storage during transportation.

6.2 Improvement measures for current equipment designs

Most of ultrasonic diagnostic equipment are terminal equipment having a configuration that places a display and operation panel in front of an sonographer who is facing to the equipment. Ultrasonography needs operation of equipment with applying a probe to an examinee; therefore, the configuration like

terminal that assumes to use with facing to the equipment is not always the best. Hence, recent ultrasonic diagnostic equipment has been improved including adjustment of the position of a display and operation panel. Use of equipment that allows such adjustment is effective for reduction of injury risks.

The height of a display and operation panel depends on whether the height of an examination table and chair is adjustable or not to the height required for achievement of ideal working posture. Improvement of equipment linked to development and spread of appropriate related equipment is essential. If it is required to deal with the possibility that examination is required to be done without height adjustment of examination table, etc., it is necessary to deal with the situation in consideration of the next best measure for equipment including a footrest.

It should be considered that ergonomic adjustment of ultrasonic diagnostic equipment would not be used unless the adjustment is easily understandable, less straining, and can be conducted quickly and safely. It is necessary to give consideration to operability including move of the position of main unit, lock of casters, adjustment of the height and position of a display and operation panel.

Items pointed out as measures for improvement are described below. The outline is shown in Table 6-1. Meanwhile, the followings are described on the assumption that a probe is held with the right hand and an operation panel is controlled with the left hand.

(1) Position of an operation panel and display

In the present circumstances, examination may be conducted in a posture that an sonographer leans the upper body toward examinee, or that an sonographer sits on an examination table in cardiac examinations. When it assumed that examinations in a such working postures are conducted many times, it is considered that it is minimally required that the end of an operation panel and display can move until contacting with the end of examination table by moving and adjustment function of the main unit (Figure 3-5). If it is assumed that right and left position of a display cannot be adjusted right in front of an sonographer, adjust the angle of the display within a corresponding range.

(2) Height of an operation panel and display

The adjustable range of the height of operation panels and displays described in these recommendations is set on the assumption that the height of operation tables is adjustable to achieve ideal working posture. However, examination tables, which are adjustable to the height as low as 300 mm, are not spread at this time. If use of such operation tables would not be assumed at all, it would be considered that the lower limit of the height indicated in the recommendations would be hardly used. Therefore, it is considered that the height of the operation panel and display would be set according to the height of the examination table actually used (if adjustable, set within the adjustable range). In such case, use of a footrest is strongly recommended when sonographer sets a chair higher. In addition, it is desired that an operation panel can be set lower as much as possible in consideration of a problem of elevation of the arm in examinations of the

lower legs that are conducted in postures with anterior inclination of the upper body and lower sitting position, and in a crouching posture.

(3) Size of an operation panel and alignment of switches, etc.

It is desired that an operation panel would be downsized to correspond to various working postures. It is ideal that the dimensions of operation panel are 300 mm or less in depth and 300 mm or less in width, and that a movable range is large as indicated in a section "3.4 Examination room, ultrasonic diagnostic equipment, and related equipment to prevent musculoskeletal disorders and eyestrain".

If the operation panel has adequate movability that enables to adjust the position of the operation panel to around the front of an sonographer corresponding to possible various postures of sonographers, including a posture that the sonographer sits on a bed and a posture that the sonographer leans the upper body toward examinee in cardiac examinations, it is preferred to set values within 450 mm, which is the average shoulder width of males. When an operation panel is large and has a limitation in movability, or when an operation panel cannot be placed in the front so that the sonographer faces to examinees, it is desired to concentrate and collect functions that are used during application of a probe into the examinee's side (the near side, usually right side) within a work area. In this regard, however, it is desired that sonographers can operate similarly even if the position of ultrasonic diagnostic equipment and sonographer becomes left and right opposite in corresponding ways.

It is desired that the wrist and forearm would be supported before a trackball or operation targets to be used intensively. Strains due to elevation of the arm can be reduced in some degree with a method that operates buttons, etc. concentrated within a range that fingers could reach without moving the upper arm and with staying the wrist and the upper arm supported. However, it is necessary to reduce a bend of the wrist and strains on fingers, and to give consideration to ease of understanding.

(4) Countermeasures to bright rooms

A standard for lighting of VDT task environment recommended in "Guidelines for Industrial Health Controls of VDT Operation" (Ministry of Health, Labor and Welfare, 2003 [5]) is 300 lux and brighter. It is desired to provide specifications of the display and main unit corresponding to the illuminance of 300 lux or brighter.

(5) Education of users about proper method for using

It is desired that manufacturers educate sonographers and managers of facilities to take full advantage of functions of ergonomically improved ultrasonic diagnostic equipment.

(6) Education and proposal of requirements for related equipment that should be introduced

It is desired to educate and propose to users about requirements for related equipment to use ultrasonic diagnostic equipment comfortably without injury risks when implementation of prolonged examinations or a number of examinations is assumed.

(7) Proposal of an integrated system

It is desired to propose and provide a system that incorporated ultrasonic diagnostic equipment with an examination table that can be used without injury risks. In this case, it is not always the best way to fulfill the conditions indicated in these recommendations if the injury risks of the assumed working posture are reduced in the system.

Table 6-1. Outline of recommendations for improvement measures in the present situation regarding equipment design

Item	Outline
(1) Position of an operation panel and display	It is minimally required that the end of them can move until contacting with the end of examination table by moving and adjustment function of the main unit.
(2) Height of an operation panel and display	- If use of an examination table that is adjustable to low position of 300 mm height and described in these recommendation is not assumed, the height of an operation panel and display may be set according to the height (or adjustable range) of the examination table. In such cases, use of a footrest is strongly recommended when an sonographer sets a chair higher. - It is desired that an operation panel can be set lower as much as possible in consideration of examinations of the lower legs in postures with anterior inclination of the upper body and lower sitting position, and in a crouching posture.
(3) Size of an operation panel and alignment of switches, etc.	- A small operation panel (300 mm or less in depth and 300 mm or less in width) is desired. If the size of operation panel cannot be downsized, concentrate and collect functions that are used during application of a probe into the examinee's side (the near side, right side) within a work area. Prepare so that sonographers can operate in the same manner even if the position of ultrasonic diagnostic equipment and sonographer becomes left and right opposite. - Provide a support to place the wrist or the upper arm.
(4) Correspondence to bright rooms	Improve specifications for displays and indication of the main unit corresponding to illuminance of 300 lux or brighter.
(5) Education of users about proper method for using	Manufacturers educate sonographers and managers of facilities to take full advantage of functions of ergonomically improved ultrasonic diagnostic equipment.
(6) Education and proposal of requirements for related equipment that should be introduced	Educate and propose to users about requirements for related equipment to use ultrasonic diagnostic equipment comfortably without injury risks.
(7) Proposal of an integrated system	Propose and provide a system that incorporated ultrasonic diagnostic equipment with an examination table that can be used without injury risks.

6.3 Development of related equipment

6.3.1 Development of dedicated examination tables for ultrasonography

It is considered that development and spread of dedicated examination tables for ultrasonography to optimize working posture during ultrasonography is the most effective and important issue for reduction of workloads on sonographers and prevention of musculoskeletal disorders in sonographers. Position adjustment of examinee, which is important to reduce workload of sonographers in current examination methods, include to bring the examinee near to the sonographer, adjustment of the height, Gatch up, adjustment of up-and-down position (position of examinees in a head-foot direction), and adjustment of right-and-left declination (to move a distant region closer). Items regarding development and spread of examination tables are shown below. The outline is shown in Table 6-2.

(1) Height adjustable examination tables

It is considered that spread of height adjustable and inexpensive examination tables is extremely important. It is necessary that examination tables are height adjustable to enable appropriate postures that the soles of feet stably touch on the floor in a sitting position on a chair as the basis. It is considered that it is especially effective to make examination tables height adjustable so that the table can be lowered to the height that sonographers can examine with bending their elbow at the angle of about 90º without elevating the right arm holding a probe in appropriate sitting position in examinations of the abdomen, breast, and neck (An adjustable range that covers 90% of both male and female Japanese: 300 - 570 mm, see Figure 3-7).

(2) Dedicated examination tables for cardiac examination

Examination tables that have a projecting part to be seated are effective for cardiac examination to reduce a twist of the lower back of sonographers. However, such projecting part hinders other examinations; therefore, it is desired to devise a design that can easily switch the function. Examination tables for cardiac examination that have a dent the near the chest region of examinees in the opposite side of an sonographer are recommended. However, there are problems in the posture during examination that an sonographer sits on an examination table and examines in a position that stretch sonographer's body over the examinee and completely stretch the arm; therefore, it is desired that ultrasonic diagnostic equipment and examination methods are fundamentally improved.

(3) Examination tables for blood vessel of the lower extremity

Development of examination tables that can safely adjust examinees in a high position is desired to avoid bending down and crouching postures of sonographers in examinations of the lower extremities that sonographers conduct in a sitting position. It is considered effective in the present situation to examine

examinees in a supine position if possible, and to use a chair which is adjustable to lower position than usual or use a platform to be seated so that a panel can be placed in an adequately low position at hand and a display can be adjusted to the front of the sonographers as much as possible.

(4) Dedicated examination tables that allow declination adjustment of examinee

Development of examination tables that allows right-and-left declination adjustment of examinee is also effective to facilitate examination of a distant (the left side) region of the heart and abdomen.

(5) Examination tables that allow adjustment of examinees' up-and-down (head-feet) position

It is considered that it is effective to make the position of examination tables adjustable easily to adjust the layout of the examination room in a limited space readily. It is considered that examination tables that can slide examinees toward up and down (head-feet directions of examinees). Especially, some height adjustable heavy examination tables cannot be moved its position easily. In such cases, it is effective that the tables can slide up and down.

(6) Gatch up of examination tables

It is considered that that examination tables that can conduct the gatch up, which allows straightening up the upper body of examinees, to reduce a distance to the examined region of the upper body in examinations of the heat and abdomen is effective.

(7) Prevention of the fall of examinee

Development of bars of examination tables (beds) that prevents the fall of examinees from the examination table, and does not disturb ultrasonography is desired.

Table 6-2. Outline of recommendation regarding development of dedicated examination tables for ultrasonography

Item	Outline
(1) Height adjustable examination tables	Development and spread of height adjustable and inexpensive examination tables to enable appropriate postures that the soles of feet stably touch on the floor in a sitting position on a chair as the basis. (adjustable range: 300 - 570 mm)
(2) Dedicated examination tables for cardiac examination	- Development and spread of examination tables with a projecting part to be seated by sonographers. - Development and spread of examination tables for cardiac examination that have a dent near the chest region of examinees in the opposite side of an sonographer. - There are problems in the posture during examination that an sonographer sits on an examination table and examines in a position that stretch sonographer's body over the examinee and completely stretch the arm; therefore, it is desired that ultrasonic diagnostic equipment and examination methods would be fundamentally improved.
(3) Examination tables for blood vessel of the lower extremity	Examination tables that can safely adjust the position of examinees in a high position.
(4) Dedicated examination tables that allow inclination adjustment of examinee	Development of examination tables that allow right-and-left inclination adjustment of examinee.
(5) Examination tables that allow adjustment of examinees' up-and-down (head-feet) position	Examination tables that can slide examinees toward up and down (head-feet directions of examinees).
(6) Gatch up of examination tables	Development and spread of examination tables that can conduct the gatch up, which allows to straighten up the upper body of examinees, to reduce a distance to the examined region of the upper body in examinations of the heart and abdomen.
(7) Prevention of the fall of examinees	Development of bars of examination tables (beds) that prevents the fall of examinees from the examination table, and does not disturb ultrasonography.

6.3.2 Improvement of chairs and postures in a sitting position

It is essential that chairs for sonographers can be easily moved its position with casters, and is height adjustable. It is desired to have a footrest when the chair needs to be adjusted higher. It is preferred that the casters can be locked when it is assumed that sonographers set the chair higher and lean their upper body. It is desired to develop equipment for a sitting position to improve the twist of the upper body caused by sitting on an examination table during a cardiac examination. Recommendations regarding chairs and

postures in a sitting position are described below. The outline is shown in Table 6-3.

(1) Footrest

Suitable height of chairs for sonographer is a height that the soles of footwear stably touch on the floor, but if the examination table or the ultrasonic diagnostic equipment is not adjustable to a lower position, it is considered that the chair needs to be adjusted higher. In such cases, it is necessary to set a footrest in a suitable place. Use of a footrest that has the best-suited shape to hold both feet stably is effective.

(2) Casters and locks

Casters of chairs for sonographers are essential. In the present circumstances, it is considered that development of chairs that can lock the casters and the lock and release of the casters can be done readily and quickly is effective on the assumption that sonographers set the chair higher and lean their upper body.

(3) Chairs that can be brought closer to an examination table

In cardiac examinations, a method that an sonographer sits on a chair and leans their upper body toward the examinee side causes a problem of an inclination of the upper body, and a method that an sonographer sits on an examination table and approaches to the examinee causes a twist of the upper body. Use of dedicated examination table for cardiac examinations with a projecting part to be seated, and a method that the height of a chair is set at the same height as an examination table and an sonographer sits on both the chair and examination table reduces the twist of the upper body. A device that can stably bring a chair closer to an examination table as if the chair is a projecting part of the examination table to provide a seating surface integrating the examination table with the seating surface of the chair may be effective in examinations conducted for examinees in a supine position.

Table 6-3. Outline of recommendations regarding chairs and sitting postures

Item	Outline
(1) Footrest	Footrest that has the best-suited shape to hold both feet stably, placed in a suitable place in the case of a chair needs to be adjusted higher.
(2) Casters and locks	Chairs that can lock the casters and the lock and release of the casters can be done readily and quickly.
(3) Chairs that can be brought closer to an examination table	A device that can stably bring a chair closer to an examination table as if the chair is a projecting part of the examination table to provide a seating surface integrating the examination table with the seating surface of the chair.

6.3.3 Armrest that can reduce strains from elevation of the arms

Provision of armrests for sonographers is also effective countermeasure because strains on the arm due to elevation is reduced by the support for the arm and wrist.

(1) Dedicated armrest

Development of dedicated equipment (armrest) to support the arm to hold a probe in examination of the abdomen, breast, lower extremities, and neck is desired.

(2) Armrests of chairs

It is considered that armrests that have an optimized design for ultrasonography (that the direction of the armrest can be changed to a direction of arm stretched, that the armrest can be housed when it is not in use), in which the armrest is attached to the operation panel side when the articular angle of the upper extremity of the operation panel side is improved in some degree, or the armrest is attached to the probe side when the articular angle of the upper extremity of the probe side is improved, can be used as a measure to reduce strains.

6.4 Partial automatization of examination

To support sonographers engaging in examination involved with great workload, it is promising to promote development of methods to secure a probe using instrument without holding the probe with a hand, and technologies to automate examination.

6.5 Development of new design of ultrasonic diagnostic equipment that has low workload on sonographers

Currently, computer terminal-like main units are usually used for ultrasonic diagnostic equipment on the assumption that sonographers conduct examination facing to the equipment, and examination tables like general-purpose bed are often used; as the results, methods that a probe is applied with stretching an arm to examination regions distant from the position of an operation panel and display become the basis of examinations. Work-strains on sonographers caused by postures can be reduced in some degree because the position of displays and operation panels of ultrasonic diagnostic equipment become adjustable flexibly and widely, and the height of examination tables become adjustable; however, it is considered that fundamental solution of unnatural working postures is difficult. There are basic problems that directions of an examination region of examinee, display, and operation panel are different each other, and distances between them are far. In addition, ultrasonic diagnostic equipment and auxiliary equipment are developed separately, and dedicated auxiliary equipment for ultrasonography are rarely used. It is considered that a problem is that provision of such equipment as a system that realizes optimum positions between an examinee and sonographer is not adequate, and such system is not even used. Development of systems that can optimize positional relationship among an sonographer, examinee, operation place, and display, and that can examine comfortably and efficiently for both sonographers and examinees is desired.

7. Conclusion

These recommendations are organized items that are required for sonographers to work safely, comfortably and healthfully, for sonographers, managers of facilities, and related manufacturers based on investigation conducted by the Research and Development Team.

Investigation and analysis to develop the recommendation and preparation of a preliminary report of countermeasures in the ergonomic standpoint were conducted by the Institute for Science of Labour in the stance of a third party.

Based on this preliminary report, all members of the Research and Development Team repeatedly discussed about problems peculiar to sonographers, managers of facilities, and related manufacturers, respectively, and carefully examined items to be included into the recommendations; and then, the Institute for Science of Labour summarized the results.

Countermeasures indicated here are only goals in the ergonomic standpoint. We hope the relevant parties make an effort to achieve these recommendations as much as possible while there are various limitations.

We believe that prevention of musculoskeletal disorders in sonographers and improvement of amenity and efficiency based on ergonomic countermeasures implemented in corporation among sonographers, managers of facilities and related manufacturers indicated in these recommendations would result in provision of high quality examinations for examinees. We hope that people in various sectors who are involved in ultrasonography practice consult these recommendations.

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Acknowledgment

A part of this study was conducted as research of the Research and Development Team of the Japan Society of Ultrasonics in Medicine in fiscal years 2010 and 2011. In addition, this study was supported by a grant funding from Grant in Aid for Scientific Research by JSPS (no. 22500441).

For collection of basic data to develop these recommendations, a number of members of the Japan Society of Ultrasonics in Medicine and the Japanese Society of Sonographers cooperated with us for the study. For collection of basic data on methods of ultrasonography, members of the Ultrasound Center, Department of Clinical Laboratory, St. Marianna University School of Medicine cooperated with us. We would like to make a most cordial acknowledgment to their understanding to the purposes of this investigation and their cooperation.

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Recommendations for Sonographers
to Work Safely, Comfortably and Healthfully
— Equipment and working environment
to prevent work-related musculoskeletal disorders and eyestrain —
March 2012 (New edition)
March 2016 (Second edition)

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