Mini Review

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Ergonomics in musculoskeletal ultrasonography

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Background: Ergonomics is the science responsible for understanding the interactions between human beings and other elements in a system. In medical disciplines such as ultrasonography, Work-Related Musculoskeletal Diseases (WRMD) has a high prevalence. Shoulder, neck and wrists are the most frequent sites of injuries. The importance of the WRMD stands out because it generates significant economic and labor disabilities.

Objective: The most studied musculoskeletal lesions in professionals are related to obstetric, vascular, abdominal, and cardiac ultrasonographer practice. Thus, a search focused on musculoskeletal ultrasonography was carried out.

Methods: This manuscript is a summary of a systematic review conducted through databases (EBSCO, Pubmed, ClinicalKey) using articles and guides between 1995 and 2016; restricted to articles published in English and Spanish, and all related to musculoskeletal ultrasound practice.

Results: There are few reports related to the impact of WRMD in professional ultrasonographers despite the increased use of musculoskeletal ultrasound since the '80s, but neither the existence nor an ergonomic plan to apply to those professionals are published.

Conclusions: WRMD are increasing related to practice; the need of a wide review of the main risk factors, production mechanisms and injury prevention measures must be carried out soon.

Keywords: ultrasound ● injuries ● work-related ● workstation ● prevention

Introduction

Ergonomics is the discipline responsible for the design of environments to match the characteristics of the people who interact with it, seeking to optimize three elements: human, machine and environment. According to the International Ergonomics Association, it is defined as a scientific discipline that deals with understanding the interactions between human beings and other elements of a system, using theories, principles, data and methods to design and optimize the performance of people [1-3]. Applied ergonomics aims to make human energy more efficient by maximizing productivity and reducing fatigue and discomfort among workers [4]; by examine anatomical, physiological, and mechanical principles that can interfere with efficiency and productivity [5].

The appearance of new products, procedures and technologies make ergonomics a constantly evolving discipline. For example, the relevance of psychological and neurological factors can increase tension, perception of pain or greater physical requirement, and transition to chronicity has been established [4].

Physical ergonomics deals with the anatomical, physiological and biomechanical characteristics of the user, related to their physical activity and postures at work, over-effort, injuries of the musculoskeletal apparatus, safety, occupational health, design of work areas, among others; and this is the focus of our manuscript [1].

Ergonomics in medicine

The increase in the daily use ultrasonography in many medical subdisciplines as a diagnostic tool due to non-invasive and radiation-free nature has triggered the presence of WRMD in the ultrasonographers for more than three decades [6]. According to studies, WRMD is estimated between

63% and 91% for practitioners, compared with general population (13% and 22%) [4,7-10].

The WRMD are a common cause of pain among ultrasonographers; it has been reported that between 80% - 90.5% of them are doing their usual work with the presence of any symptoms. The consequence is chronic pain, work absence, increase in surgical procedures related with work disability and limitation to continue a professional career [2,11,12]. For example, a report from England reports 20% of WRMD in ultrasonographers that has ended their career [13]. Some other reports from USA, Canada and Europe documented 80% up to 90% of professionals suffering a WRMD [6,8,14].

Musculoskeletal injuries have been described in different subspecialties such as cardiology (echocardiography), vascular, gynecology, obstetrics and abdominal practitioners but musculoskeletal ultrasonographers are not included [11].

Origin of the injuries

Musculoskeletal diseases are caused by a biomechanical alteration in the structures that occur when joints are used repeatedly for long periods of time or due to an increase in muscle load maintaining a static position, due to a combination of biomechanical and psychosocial factors [2,4]. The main causes of WRMD according to the US Occupational Safety and Health Administration are: vibration, overuse, excessive force, and pressure, forced and abnormal movements, poor posture or positioning, repetitive movements and long duration of pressure [6].

A static posture is a fundamental event for the development of injuries because it decreases the blood flow and oxygen levels to muscle. If the muscular work is 60% of its maximum capacity the blood flow is almost completely interrupted in that area [6]; as a result, products of metabolism are released, triggering fatigue and pain [4]. If the work continued for several hours without symptoms the force generated does not exceed approximately 10% [6]; thus an adequate body posture is essential to obtain the maximum efficiency and the minimum possible fatigue [5].

Factors fully identified as the origin of WRMD in the upper extremities are sustained abduction of the shoulder, excessive pressure when holding the transducer and inclination of the wrist for long periods. If the degree of abduction of the shoulder is greater the muscles fatigue is faster. When the angle of abduction increases from 30° to 120° the fatigue time decreases from 60 to 5 minutes [9].

Ultrasonographers spend a large part of their working time sitting. Staying in this position produces a load on the intervertebral discs of the lumbar region of 140% relative to the load while standing. Consequently, sitting properly is essential to staying pain-free [4].

Ophthalmological problems are reported by ultrasonographers with WRMD; the decrease in visual acuity is reported in 19.2% [8] and susceptibility to visual syndrome by computers (VSC), associated with prolonged use of monitors who handle them for more than three hours a day is reported too. The most common symptoms are dry eye, visual fatigue, conjunctival redness, blurred vision, and headache [5]. The most common causes are insufficient light, glare by the monitor, inadequate distance or posture to the monitor, and previous unidentified ophthalmological problems [4].

Affected regions in ultrasonographers

Shoulder (73%-90%), neck (28%-74%), wrists (54%-59%), back (44.4%- 69%) and hands (55%) [6,7,9,11] are the most affected regions. Some investigations refer that the dominant side and female predominance to be the most affected [8,9].

Muscle spasms, inflammation, loss of sensation and dysesthesia usually appear. They can be transitory, persistent, or intermittent. The most common diagnosis related to occupational injuries is tenosynovitis and the most common cause is injury and repetitive load [6].

On the other hand, the use of transducers produced by holding tight while turning and twisting causes symptoms in the cervical region, shoulders, elbows, back, hands and wrist; repetition of these actions generates muscle load that accumulates progressively and decreases tissue tolerance [4]. Increase in obese population has conditioned ultrasonographers to press the transducer strongly against the patient's body to minimize the distance with the internal organs to increase the quality of the image [14]. The average force to hold the transducer during the ultrasonographic evaluation process is 3.96 kg and can be increased to more than 27.6 kg when performing an evaluation in obese patients [8].

Risk factors

Susceptibility to presenting musculoskeletal injuries varies according to each person and level of exposure to trigger the symptoms is unknown [4]. The increase

in risk factors is one of the main explanations for the prevalence of these lesions [6] and is related to different aspects, shown in Table 1.

Proper design of the workstation

The workstation is formed by the ultrasound machine, the operator, and the patient [10]. This station has presented modifications during the last two decades, going from an analogue to a digital environment [5].

The design must be based on the basic principles of ergonomics that prioritize the location of objects according to importance, the frequency of use, function, and sequence of use. It is essential to have considerations in the lighting, sound, and space [4,6].

It is important to have enough space to allow free movement around the patient [4] and it is recommended that space should be as silent as possible, because sound can increase fatigue and reduce the productivity among users [4,7].

Lighting is important; poor orientation of the workstation alters the perception of the details in the monitor, modifies the discrimination of contrasts and influences the interpretation of the studies [5].

The digital systems and the operation of their electronic components cause elevation of the temperature in the room; causing discomfort in the eyes by increasing dryness of the air, triggering abnormal positions and WRMD [5].

The maximum number of people who must remain in the workstation is three; an ultrasonographer and two additional people (training or nurses). This reduce the level of stress generated by distractions; location of the people who are not performing the evaluation is posterior and lateral to the operator´s area [5].

Prevention

Before beginning a musculoskeletal ultrasound study it is important to have a few minutes to optimize the position of the patient and the equipment. The following actions are recommended: to corroborate a good posture with less tension [2], to be as close as possible to the patient [7,10], and to eliminate the anomalous postures inherent in the use of many types of ultrasound equipment [14]. The structure of a workstation must be adapted to a specific user [5].

The position of the chair, table, keyboard, and monitors must be designed to obtain maximum comfort and efficiency. Mobile elements must be adapted to the person and not the other way [5]. Lightweight chairs ergonomically designed with wheels, adjustable and with backrest are suggested. The knees of the operator, standing, should be between 3 to 5 cm above the seat [4]. The chair should provide good lumbar support,

Table 1. Risk factors to develop WRMD.

Time	- Five years of regular practice in ultrasonography [8].
	- More than 10 years of experience in the field [11].
	- To perform at least 100 evaluations per month with an average duration of 25 minutes [8].
	- To perform ultrasound for more than 4 hours a day [13].
	- To do evaluations around 7 hours a day for 2 days [7].
Posture and body composition	- Repeated isometric postures [8].
	- The position of the wrist that interferes with the muscular activity of the forearm [4,7].
	- The association of prolonged periods of pressure with substantial pressure peaks and discomfort in the grip of the probe [8].
	- Turning the neck and trunk constantly [14].
	- The abduction of the shoulder more than 30° [8].
	- Size and muscle mass of the evaluator [9,14].
Area of specialization	- Ultrasonographers who are specialized in a single modality [6].
	- Vascular department specialization [11].
Workstation	- Not adjustable equipment [7].
	- Monitor on the left side [11].
	- The upper level of the monitor above the level of the eyes [5,11].
	- Using portable equipment to work [14].
Work environment	- The increasing demand of the ultrasonography service associated with a low control of the evaluation schedules [14].
	- Patients with prolonged waiting [7].
	- High level of interaction with other people and difficult to handle patients [4].
	- Stress and bad attitude of the ultrasonographer [2,9]

Table 2. Important aspects to prevent lesions.
Minimize noise lower than 58 dB, or as much as possible [4,5].
Indirect light and the option to controlled it gradually [6].
If the use of additional external lighting is required, it should be fluorescent and indirect, placed above the head to avoid glare [5].
It is recommended that the walls are painted in neutral and matte colours to reduce the reflection of light [5].
Ventilation systems and temperature regulation (the optimum temperature is between 20°C – 25°C) [5].
Optimal humidity between 40 and 60% [5].

without causing excessive pressure on the lower part of the thighs, with the feet resting on the floor and an angle between the thighs and the legs between 90 and 105 degrees [5].

To prevent ophthalmological conditions it is recommended that the monitor should be placed at the height of the operator; the top margin should not be above the eyes and the distance of separation is recommended between 50cm and 75cm. If this is not possible, a good option is to increase the size of the text or image instead of moving the monitor closer. It is also recommended to visit the ophthalmologist to preventive evaluations and to correct minor vision defects [4,5]. Ultrasonographer should not spend more than 2 continuous hours with the eyes focused on the monitor, interruptions of 15 minutes every 2 hours is a good action of prevention [4].

In obese patients, it is suggested to take small breaks during the ultrasound study [2]. Rest periods are essential to use these times assertively to change the work environment and perform activities that use different muscle groups. Small breaks should be made to rest the eyes and the posture, it is recommended to get away at least 20 steps from the screen, every 20 minutes of time and for 20 to 30 seconds [5]. Ultrasonographers who vary their posture while performing evaluations experience relief of musculoskeletal symptoms [4]. Table 2 shows actions recommended.

In several studies, it has been documented that the ultrasonographer with a reduced muscle mass presents a higher risk of injury, so it is suggested to increase muscle mass with exercise. Physical activity also reduces stress and improves self-esteem. A good alternative is swimming and performing pilates [2]. This lifestyle is important in the prevention of WRMD because those who spend their free time in passive activities are twice likely to develop lesions compared to those who are more active [13].

Conclusions

The evidence demonstrates the presence of WRMD in ultrasonographers raised to more than 90% but there is scarce evidence in the group of professionals focused on the musculoskeletal system. In this context, there are particularities in the practice for musculoskeletal ultrasonographers, which establish the need for research that allow the recognition of the main problems of ergonomics, allowing the designing of management planning that includes universities, ultrasonographers and research centres.

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References

1. https://www.iea.cc/whats/index.html
2. Harrison G, Harris A. Work-related musculoskeletal disorders in ultrasound: Can you reduce risk? *Ultrasound.* 23(4), 224-230 (2015).
3. Ashok-Gupta A, Ashok-Mhaske S, Ajaz-Ahmad M *et al.* Ergonomic Microscope: Need of the Hour. *J. Clin. Diagn. Res.* 95, 62–65 (2015).
4. Brusin JY. Ergonomics in Radiology. *Radiol. Technol.* 83(2), 14–157 (2011).
5. Garcia-Lallana A, Viteri-Ramirez G, Saiz-Mendiguren R *et al.* Ergonomía en el puesto de trabajo en radiología. *Radiología.* 53(6), 507–515 (2011).
6. Baker JP, Coffin CT. The importance of an Ergonomic Workstation to Practicing Sonographers. *J. Ultrasound. Med.* 32(8), 1363–1375 (2013).
7. Friesen MN, Friesen R, Quanbury A *et al.* Musculoskeletal Injuries Among Ultrasound Sonographers in Rural Manitoba. A Study of Workplace Ergonomics. *AAOHN. J.* 54(1), 32–37 (2006).
8. Rousseau T, Mottet N, Mace G *et al.* Practice Guidelines for Prevention of Musculoskeletal Disorders in Obstetric Sonography. *J. Ultrasound. Med.* 32(1), 157–164 (2013).
9. Roll SC, Selhorst L, Evans KD. Contribution of Positioning to Work-Related Musculoskeletal Discomfort in Diagnostic Medical Sonographers. *Work.* 47(2), 253–260 (2014).

10. Yazdani A, Neumann WP, Imbeau D *et al.* Prevention of musculoskeletal disorders within management systems: A scoping review of practices approaches, and techniques. *Appl. Ergon.* 51, 255–262 (2015).

11. Claes F, Berger J, Stassinjs G. Arm and Neck Pain in Ultrasonographers. *Hum. Factors.* 57(2), 238–245 (2015).

12. Simonsen JG, Gard G. Swedish Sonographers perceptions of ergonomic problems at work and their suggestions for improvement. *BMC. Musculoskelet. Disord.* 17(1), 391 (2016).

13. Bolton GC, Cox DL. Survey of UK Sonographers on the Prevention of Work-Related Muscular-Skeletal Disorder (WRMSD). *J. Clin. Ultrasound.* 43(3), 145–153 (2015).

14. Roll S, Evans KD, Hutmire CD *et al.* An analysis of occupational factors related to shoulder discomfort in diagnostic medical sonographers and vascular technologist. *Work.* 42(3), 355–365 (2012).