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Radiographers' musculoskeletal health in Western Switzerland: a need for occupational prevention programs

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
CCTRM	Collège des Chefs TRM
CHUV	Centre Hospitalier Universitaire Vaudois
CI	Confidence interval
CR	Conventional radiography
CT	Computed tomography
DIR	Diagnostics and Interventional Radiography
HESAV	Haute École de Santé de Vaud
HRO	Human Research Ordinance
IQR	Interquartile range
ISO	International Organization for Standardization
M	Median
MN	Nuclear Medicine
MRI	Magnetic resonance imaging
MSDs	Musculoskeletal disorders
N/M	Not measurable
NMQ	Nordic Musculoskeletal Questionnaire
NPRS	Numeric pain rating scale
OR	Odd ratio
PACS	Picture archiving and communication system
PET	Positron emission tomography
PET	Positron emission tomography
RT	Radiotherapy
SD	Standard deviation
SPECT	Single photon emission computed tomography
TMSLT	Troubles musculo-squelettiques liés au travail
TR	Technical Report
TRM	Technicien en radiologie médicale
WRMSDs	Work-related musculoskeletal disorders

ABSTRACT

Purpose This study aimed to characterize Radiographers, from Western Switzerland, work-related musculoskeletal disorders (WRMSDs) symptoms prevalence, severity, and work-related risk factors, including posture analysis at performing bedside chest plain radiography.

Methods A cross-sectional study was conducted in two phases: a) online survey based on the Nordic Musculoskeletal Questionnaire (NMQ) addressed to radiographers of Western Switzerland to characterize WRMSDs; b) observation of practice and simulation of key tasks to assess the postures assumed by radiographers performing bedside chest plain radiography. The main body segments' angles were measured with a dedicated software and classified according to the European standards (EN1005–4: 2005).

Results From the 359 survey participants, 94.7% presented WRMSDs symptoms in the last 12 months, with a related absenteeism rate of 15.6%. The WRMSDs symptoms prevalence in the last 7 days was lower (67.7%), but a high pain intensity and frequency was observed. For both time periods, the most reported symptoms were on the neck, upper back, lower back and shoulders. Among risk factors identified for the WRMSDs of the last 12 months, awkward postures increased the chances of neck (OR=2.22; 95% CI 1.26-3.92) and lower back symptoms (OR=2.86; 95% CI 1.78-4.58), as well the use of physical force increase (OR=2.18; 95% CI 1.30-3.65) in lower back pain.

The simulations of practice revealed that radiographers adopted awkward postures during bedside chest plain radiography performance. The "non-acceptable" postures were observed mainly in upper arms and head/neck during patient handling and X-ray tube manipulation.

Conclusions: WRMSDs symptoms are common in radiographers of Western Switzerland, with absenteeism in 15.6% of the cases. The results showed a multifactorial source of the symptoms, namely from ergonomic, physical, and organizational/psychosocial risk factors and individual characteristics. Radiographers' tasks during bedside chest plain radiography required working in awkward postures leading to WRMSDs symptoms. This shows the need to improve radiographers working conditions though prevention programs to reduce these occupational health problems.

Key-words: Occupational health; Posture assessment; Ergonomics; Work conditions; Pain; Discomfort.

RÉSUMÉ

Objectifs Les objectifs de cette étude étaient de caractériser la prévalence, la sévérité et les facteurs de risque des troubles musculo-squelettiques liés au travail (TMSLT) chez les techniciens en radiologie médicale (TRM) de Suisse occidentale, ainsi que de caractériser leurs pratiques lors de la réalisation de radiographies de thorax au lit.

Méthodes Une étude transversale a été menée sur les TMSLT en deux phases : a) une enquête en ligne basée sur le questionnaire nordique a été adressée aux TRM de Suisse romande afin de caractériser les TMSLT ; b) des méthodes d'observation et de simulation ont été utilisées afin d'identifier les tâches clés et d'évaluer les postures adoptées par les TRM lors des radiographies du thorax au lit. Les angles des principaux segments corporels ont été mesurés à l'aide d'un logiciel approprié et classés selon des normes européennes (EN1005-4 : 2005).

Résultats Sur les 359 participants à l'enquête, 94,7% ont souffert de symptômes musculo-squelettiques au cours des 12 derniers mois avec un taux d'absentéisme de 15.6%. La prévalence des symptômes au cours des 7 derniers jours était plus basse (67.7%) mais avec une intensité et une fréquence élevée de la douleur. Pour les deux périodes, les symptômes touchaient principalement le cou, le haut et le bas du dos, ainsi que les épaules. Parmi les facteurs de risque associés aux symptômes des 12 derniers mois, les postures contraignantes ont été identifiée comme augmentant le risque de symptômes au niveau cervical (OR=2,22 ; IC 95 % 1,26-3,92) et lombaire (OR=2,86 ; IC 95 % 1,78-4,58), de même l'usage de la force physique augmenterait le risque de symptômes lombaires (OR=2,18 ; IC 95 % 1,30-3,65).

Les simulations ont révélé, quant à elles, que les TRM adoptaient des postures contraignantes lors de la réalisation de radiographies de thorax au lit. Les postures "non-acceptables" ont été observées principalement au niveau des bras et de la tête/cou lors de la manipulation des patients et du tube radiologique.

Conclusions Les TMSLT sont fréquents chez les TRM de Suisse occidentale avec un taux absentéisme de 15.6%. Les résultats attestent de la nature multifactorielle des symptômes, à savoir les facteurs de types ergonomiques, physiques, organisationnels/psychosociaux et aux caractéristiques individuelles. Les tâches des TRM lors de la réalisation de radiographies de thorax au lit exigent de travailler dans des postures contraignantes, ce qui peut entraîner des symptômes musculo-squelettiques. Ces résultats soulignent le besoin d'améliorer les conditions de travail des TRM au travers de programmes de prévention afin de réduire ce problème de santé occupationnel.

1 INTRODUCTION

Musculoskeletal disorders (MSDs) are impairments of anatomical structures such as muscles, joints, tendons, ligaments, nerves, cartilage, bones and the localized blood circulation system (European Occupational Safety and Health Administration, 2007). If MSDs are caused or aggravated primarily by work and by the effects of the immediate environment in which work is carried out, they are known as work-related musculoskeletal disorders (WRMSDs) (European Occupational Safety and Health Administration, 2019). WRMSDs are typically a consequence of being exposed to occupational risk factors such as awkward postures, application of force, and repetitive movements (European Occupational Safety and Health Administration, 2019).

WRMSDs are a significant public health concern due to its high prevalence in Europe (European Occupational Safety and Health Administration, 2019; Rieker-Agranier & Golay, 2008). The main consequences of these disorders are the absenteeism, early retirement, loss of performance and productivity, which leads to a high financial and social burden (Delalande-Danet et al., 2015; European Occupational Safety and Health Administration, 2019).

Healthcare workers are particularly prone to develop musculoskeletal symptoms due to the high levels of stress, high demand of physical and mental efforts (Sikorski, 2009). Among healthcare workers with a high prevalence of WRMSDs are the radiographers (Pompeii et al., 2008) due to high physical work demands during patients manipulation, use of heavy equipment's (Hulls et al., 2018; Kumar et al., 2004b; Pompeii et al., 2009), and increased workload at Radiology Services (Hulls et al., 2018; Verrier & Harvey, 2010). A special attention to improve radiographers' work conditions is required to prevent patient safety issues (including healthcare workers health) and quality assurance problems, since both seem to be related (Sousa Uva & Serranheira, 2014).

The high prevalence of WRMSDs in radiographers indicates the need of a risk management plan and the implementation of preventive measures to reduce or eliminate the exposure to the risks factors (Centers for Disease Control and Prevention, n.d.; European Occupational Safety and Health Administration, 2019). Directives for safety and health at work and prevention programs have been set up in last decades to reduce the incidence and prevalence of work-related disorders (Council Directive 89/391/CEE of 12th June 1989). The integration of ergonomics into the workplace is one of the strategies to prevent WRMSDs and reduce their associated costs (Griffin, 2018; Springer, 2007). Ergonomic assessments can lead to improvements in work conditions, higher performance, well-being, productivity, better health and safety (Springer, 2007). Consequently, risks and adverse events or errors reduction, and

an increase of patient safety and quality of care can be observed (Sousa et al., 2009; Sousa Uva & Serranheira, 2014).

1.1 STATEMENT OF THE PROBLEM, AIMS AND OBJECTIVES

Swiss law, as European directives, supports occupational health and considers employers as responsible for ensuring employees' health and security (Art. 6 Loi Fédérale du 13 mars 1964 sur le travail [LTr]; Art. 2 & Art. 3 Ordonnance 1 du 10 mai 2000 relative à la loi sur le travail [OLT 1]) by taking all necessary measures and providing adequate education in terms of ergonomics and health protection at work (Art. 2 & Art. 3 Ordonnance 3 du 18 Août 1993 relative à la loi sur le travail [OLT 3]; Art. 27 & Art. 32a Ordonnance du 19 décembre 1983 sur la prévention des accidents [OPA]). However, the WRMSDs remain the most common work-related health problem and important cause of work absences corresponding to an economic loss of 4.5 billion Swiss francs (CHF) per year (Läubli & Müller, 2009). Swiss healthcare workers are affected, having the highest number of absences and career interruptions due to illness (Rothweiler, 2019). Radiographers are an example of a high prevalence of WRMSDs due to the risk factors present in radiology departments (Lorusso et al., 2007; Pompeii et al., 2008). Nevertheless, the published literature focusses mainly nursing, letting other healthcare workers underexplored. Even having some similarity in the daily occupational activities of health professions (nurses, radiographers, physiotherapists, etc.), findings and recommendations described in nursing studies are not always directly applicable to radiographers (Bos et al., 2007; Pompeii et al., 2008). The Swiss context is not fully explored regarding radiographers and the existing literature overlaps radiological fields or it focuses on diagnostic radiographers and/or sonographers. A comprehensive understanding needs further investigations to explore the Swiss context for radiographers in all fields.

In daily work, radiographers are exposed to demanding working conditions (Bright Ofori-Manteaw et al., 2015), such as patient handling and radiological equipment manipulation (Siegal et al., 2010). The physical force, awkward postures and repetitive movement were already identified in healthcare fields (Costa et al., 2014; Pompeii et al., 2009; Ribeiro et al., 2017; Weiner et al., 2017), demonstrating the need for ergonomic assessment and interventions to reduce the risks (Cernean et al., 2017). Diagnostic radiographers also endorse these hazardous activities, notably during bedside chest X-rays (Kumar et al., 2003; Pompeii et al., 2009), one of the most common requested examinations in conventional radiology (Enevoldsen & Kusk, 2020). This examination often involves bedridden patients who may be unable to collaborate (Rubinowitz et al., 2007), requiring from radiographers a physical effort to perform the examination (Krebs et al., 2007; Kumar et al., 2003, 2004b; Weiner et al., 2017).

Besides, the requests have even increased with the Corona Virus scenario due to its importance in the detection and follow-up of patients (Cleverley et al., 2020; Fechner et al., 2020) increasing the workload and physical demands. It can be assumed that bedside chest X-ray examinations may contribute to WRMSDs in diagnostic radiographers. However, little is known about radiographers' work, making it challenging to optimize and improve practice. Postures adopted during radiographers' work need to be assessed to build an ergonomic strategy to prevent WRMSDs (Centers for Disease Control and Prevention, n.d.). The ergonomics regarding equipment also needs to be considered to improve the interaction between man and machine and reduce risks (British Standard, 2018).

A baseline needs to be buildup considering occupational risks for radiographers to later provide useful information to equipment designers and/or to plan interventions for prevent, reduce or eliminate the exposures, reducing consequently the incidence and prevalence of WRMSDs (Centers for Disease Control and Prevention, n.d.; Oakman et al., 2014).

1.1.1 Aims and objectives

The aims of this study were to characterize WRMSDs symptoms in radiographers from the three fields of western Switzerland and to characterize postures assumed by radiographers during bedside chest plain radiography performed. As specific objectives, this study allowed to:

a. Identify the prevalence and severity of WRMSDs symptoms;
b. Investigate associations between WRMSDs symptoms and risk factors.
c. Determine prescribed work and real work during equipment handling and bedridden patient positioning;
d. Measure and classify joints angles (head/neck, trunk and upper arms) according to European Standards (EN 1005-4:2005 + A1:2008) during equipment and patient handling during bedside chest plain radiography;
e. Make medical imaging departments aware of the need to take into consideration the health and safety of radiographers to ensure quality of care.

1.2 THESIS STRUCTURE

The structure of this thesis is composed of five chapters: 1) Introduction, 2) State of the art, 3) Methodology, 4) Results, 5) Discussion, 6) Conclusions and 7) Recommendations and further work.

Chapter 1 introduces the topic and settles the problem and objectives of the research.

Chapter 2 presents the definition of WRMSDs, associated risks factors, the context of radiographers and provides a summary of the purpose of the study

Chapter 3 presents the methodology design and the ethical considerations organized in two sections corresponding to the aims of the study, respectively: i) characterization of WRMSDs symptoms in radiographers, and ii) the characterization of the radiographers' posture.

Chapters 4 and 5 present and discuss the results of the study in two structured sections according to the phases of the study.

Chapters 6 presents the conclusions summarizing the main findings according to the objectives.

Chapter 7 presents recommendations and further work for efficient prevention strategies to address the identified risk factors.

2 STATE OF THE ART

This chapter provides a general overview of WRMSDs, namely definition, symptoms and risk factors followed by the current specificities regarding radiographers' profession.

2.1 WRMSDS DEFINITION AND SYMPTOMS

The musculoskeletal disorders refer to a locomotor impairment affecting musculoskeletal system and connective tissue such as joints, muscles, tendons, ligaments, nerves, bones and/or local blood circulation. These group of disorders can be caused by an imbalance between work demands and radiographers physiological capacities (Luttmann et al., 2004) that frequently originates WRMSDs (Centers for Disease Control and Prevention, 2020; European Occupational Safety and Health Administration, 2007). The WRMSDs can be a result of repetitive and frequent work activities, awkward postures, force demands or even from an acute trauma such as a fall. However, they may also be related to daily and/or personal activities (e.g., sports) (Luttmann et al., 2004).

The anatomical regions typically affected by these group of disorders are the back, neck, shoulders and upper limbs, while lower limbs are generally less affected (European Occupational Safety and Health Administration, 2007, 2019). The symptoms are characterized by discomfort, aches, or pain, induced by inflammatory or degenerative responses affecting one or multiple anatomical regions (Conne-Perréard et al., 2001; European Occupational Safety and Health Administration, 2019). WRMSDs are classified by affected anatomical regions, when the symptoms are ill-defined, such as backpain (Nunes & McCauley, 2012) or

by pathology when symptoms are defined such as tendonitis, tenosynovitis, bursitis, canal syndrome, rachialgia and radiculalgia (Delalande-Danet et al., 2015). It can also be classified as acute and transitory, severe and chronic disorder (European Occupational Safety and Health Administration, 2019; Luttmann et al., 2004). Acute lesions are mainly caused by heavy loads for a short period of time, while chronic injuries result from repetitive overload and trauma over time (Luttmann et al., 2004).

2.2 WRMSDs RISKS FACTORS

2.2.1 WRMSDs theorical framework

The aetiology of WRMSDs is multifactorial since it can result from a combination of physical factors (including ergonomic risk factors), organizational and psychosocial risk factors, and individual characteristics).

Several frameworks have emerged to explain the mechanism leading to WRMSDs (Karsh, 2006) being divided into three main models: biomedical, biopsychosocial, and ergonomic or organizational models. The biomedical model is interested in the causal relationship between pathology, biomechanical, and neurobiological factors. The biopsychosocial model adds social and psychosocial to biomedical models and the ergonomic model integrates organizational factors with the two other models, being the most comprehensive model (European Occupational Safety and Health Administration, 2019; Macdonald, 2012; Macdonald & Oakman, 2015).

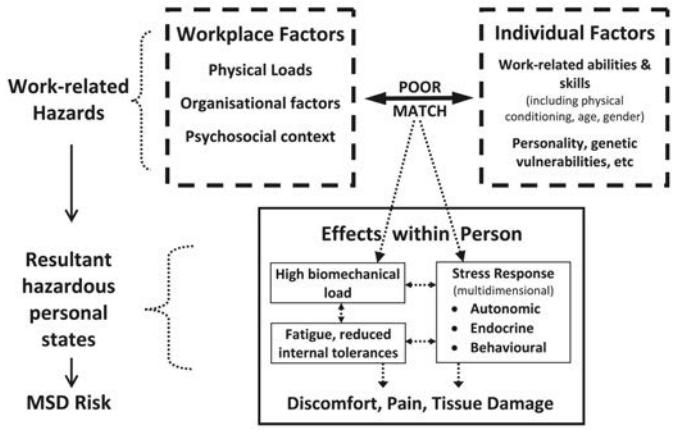


Figure 1 - Theoretical framework for WRMSDs development (Macdonald, 2012; Macdonald & Oakman, 2015).

Biopsychological theoretical framework of Macdonald & Oakman's (2015) (Figure 1) comprises three workplace risk factors: physical load, organizational factors, and psychosocial context. Individual factors are also included in the model since a mismatch between work requirements and individual factors may affect workers status. The consequences of the poor

match are a cyclic reaction where high biomechanical loads induce a stress response resulting (multidimensional, including at local and systemic level) in fatigue and reduced internal tolerances. This chain reactions leads to the risk of developing WRMSDs symptoms such as discomfort, pain and tissue damage (Macdonald, 2012; Macdonald & Oakman, 2015).

2.2.2 Ergonomic risk factors

Ergonomic risk factors are a subset of workplace risk factors mainly identifiable when workers do their job and includes awkward postures, physical effort, repeated movements, and static postures. This group represents the main cause of WRMSDs, as there are no WRMSDs without physical demands (Delalande-Danet et al., 2015) and the risk is even increased when there is high intensity solicitation, high repetition frequency, and long exposure times (Conne-Perréard et al., 2001; Delalande-Danet et al., 2015).

The postural constraints may arise from the accessibility, shape, tools utilization mode, professional activities requiring the worker to bend, stretch, twist, and kneel, which can lead to locomotor system injuries. Further the body's posture deviates from the neutral position, more the position is considered awkward (Aurelia-Mihaela et al., 2020), and when maintained over time, it becomes physiologically harmful (Delalande-Danet et al., 2015). The type of movement also needs to be considered because when it is outside the comfort range of movement for the joint it can result in injury (Delalande-Danet et al., 2015; Luttmann et al., 2004).

The static postures can also be problematic due to the load induced by muscle contraction to maintain the body in a certain posture over a long period of time. Prolonged contraction results in muscular fatigue due to compression of tendons, nerves, or vascular structures. Poor muscles irrigation can also be observed, leading to the accumulation of lactic acid, which causes pain and WRMSDs (Delalande-Danet et al., 2015; Luttmann et al., 2004).

The consequences related to muscle loads depend mainly on the intensity of the applied force (Luttmann et al., 2004). Each muscle and body segment have the capacity to produce more or less mechanical work. The more intense the effort is perceived, the closer the force exerted is to the maximal capacity of the muscle (Delalande-Danet et al., 2015). Other parameters such as the engaged body part, the posture, the grip of the object, and the effort direction are necessary to determine force intensity. The risk of developing WRMSDs is increased when the individual physiological capacities and recovery time are not respected (Delalande-Danet et al., 2015).

Repeated and sustained use of the same joints and muscles are risk factors for the development of WRMSDs (Delalande-Danet et al., 2015; Luttmann et al., 2004). The same movement often repeated and quickly performed over a long period of time, is a risk factor and

increases if there if there is not sufficient recovery time. Two quantitative definitions are mainly used to define repetitiveness: a) task with a cycle time inferior to 30 seconds, b) sequences mobilizing the same body segments for more than half of the working time (Delalande-Danet et al., 2015).

2.2.3 Physical risk factors

Physical risk factors refers to the layout and conditions of the workplace, environment conditions, characteristics of the equipment and furniture in the workplace (Iowa State University, n.d.; World Health Organization, 2010) imposing working conditions which may affect the health of the workers (Schmitter, 2010). Physical work environment combined with other of risk factors influence physiological imbalance and contribute to the development of WRMSDs (Delalande-Danet et al., 2015; European Occupational Safety and Health Administration, 2019).

2.2.4 Organizational and psychosocial risk factors

Organizational and psychological factors may be used as synonyms. Nevertheless, the inclusion of psychological factors adds an emotional dimension – stress response induced by a negative perception of the professional activity. This group includes "[…] organizational culture, attitudes, values, beliefs and daily practices in the enterprise […]" (WHO, 2010, p.15), such as work pace, work organization, management style, lack of support and fear of losing the work (World Health Organization, 2010), "[…] that affect the mental and physical well-being of employees" (WHO, 2010, p.15). Even if they are not directly responsible for WRMSDs (Gezondheidsraad, 2000 cited by Nunes & McCauley, 2012) their interactions with ergonomic risk factors increase the chance of WRMSDs symptoms (Nunes & McCauley, 2012).

2.2.5 Individual factors

Individual factors are the personal characteristics influencing the WRMSDs likelihood and it includes sociodemographic (e.g., gender, age, anthropometrics), and lifestyle characteristics (e.g., sport activity, tobacco consummation, alcohol habits) (European Occupational Safety and Health Administration, 2019). However, the impact and association between these factors and WRMSDs are variable in the published literature, and therefore, it does not explain unequivocally the onset of WRMSDs (Delalande-Danet et al., 2015; Nunes & McCauley, 2012). This group of risk factors possibly acts as moderator and aggravator meaning that they do not directly affect WRMSDs occurrence, but influence and change workers musculoskeletal response to work related factors (European Occupational Safety and Health Administration, 2019).

2.3 WRMSDs IN RADIOGRAPHERS' CONTEXT

In Switzerland, undergraduate curriculum enables radiographers to practice in three radiological fields: diagnostic and interventional radiology (DIR), nuclear medicine (MN) and radiotherapy (RT). In diagnostic radiology radiographers perform examinations using ionizing or electromagnetic radiation. Nuclear medicine uses radiopharmaceuticals in order to image or treat patients, while radiotherapy focuses on cancer treatments or other diseases by administering radiation. In all those fields, radiographers are responsible for patient care and image acquisition and/or treatment. In those tasks, several require awkward positions and application of force, notably to handle patients and manipulate heavy radiological equipment, which are considered as risk factors that may lead to WRMSDs (Kumar et al., 2004b; Pompeii et al., 2009; Ribeiro et al., 2017; Weiner et al., 2017).

The increase of imaging demands required to work in a small team for twenty-four seven service (Bright Ofori-Manteaw et al., 2015; Kumar et al., 2004b) to manage inpatients and outpatients from different contexts as emergency, ambulatory, operating room and intensive care units (Kumar et al., 2004b). Furthermore, growing complexity of radiological examinations and intensification of multidisciplinary approaches may also generate a significant mental burden with stress reaction contributing to increase the risk of WRMSDs (Goyette, 2016; Hulls et al., 2018; Kumar et al., 2004b; Verrier & Harvey, 2010).

2.3.1 WRMSDs prevalence and symptoms in radiographers

WRMSDs are frequently observed in radiographers (Daniel et al., 2018). However, prevalence, and symptoms are slightly dependent on studies and imaging modalities (Griffin, 2018; Lorusso et al., 2007; Pompeii et al., 2008; Siewert et al., 2013; Tinetti & Thoirs, 2019). These differences may be explained by the research settings, as well as the differences in practice and equipment available in the 3 domains.

Previous studies dedicated to diagnostic radiographers showed a prevalence ranging from 67% (Lorusso et al., 2007) to 93% (Daniel et al., 2018) of WRMSDs with back, neck and upper limbs, as the most affected anatomical regions (Bright Ofori-Manteaw et al., 2015; Kumar et al., 2004b; Lorusso et al., 2007). The WRMSDs are specific to each modality. Lower back symptoms are most typical on magnetic resonance imaging (MRI) and interventional radiographers, while neck symptoms are more observed in mammography and computed tomography (CT). CT radiographers are also affected by wrist and hand symptoms frequently, while shoulders symptoms are observed on radiographers working in conventional radiography (CR) (Lamar, 2004).

In other imaging specialties such as sonography, radiographers showed to be particularly exposed to risk factors with a prevalence of WRMSDs over 90% (Tinetti & Thoirs, 2019). The neck, shoulder, and wrist/hand are the most affected anatomical areas (Evans, Roll, & Baker, 2009; Ransom, 2002), notably due to specific wrist and body movements during the scanning (Ransom, 2002).

WRMSDs are also present amongst therapeutic radiographers, with main complaints on lower back, neck, and shoulder (Evans et al., 2019; Griffin, 2018; Hanania et al., 2020).

Radiographers tend to postpone the treatment of their injuries but the time elapsed between the onset of WRMSDs and treatment is crucial as it affects the chance of successful recovery (Goyette, 2016). For this reason, radiographer's health should be analyzed in occupational health appointments and, if needed, changes in environmental and organizational work should be done to prevent these occupational disorders. They should also be encouraged to report to the occupational physician at the earliest stage of symptoms.

2.3.2 WRMSDs risk factors in radiographers

The prevalence and symptoms associated to WRMSDs shows that radiographers are exposed to occupational risk factors and individual characteristics influencing the likelihood for occurrence of WRMSDs (Alhasan, Abdelrahman, Alewaidat, Almhdawi, & Nazzal, 2014; Daniel et al., 2018; Eslick & Raj, 2002; Hulls et al., 2018; Maumet et al., 2005; Ribeiro et al., 2016; Siegal et al., 2010), with age, workload, and well-being as best predictors (Augner & Kaiser, 2019).

Main ergonomic risk factors threaten radiographers health in Conventional Radiology are the adoption of awkward joints angles while positioning the detector under the patient contributing to upper extremity and low-back pain (Kumar et al., 2004b). This problem was also identified in mammography, where awkward postures are adopted such as twisting the body and using unacceptable joints angles due to technical requirements for breast positioning and equipment handling. The adopted awkward postures may increase WRMSDs (Costa, Oliveira, Reis, Viegas, & Serranheira, 2014), mainly when there are anthropometric differences between the radiographer and the patient. The risks are increased since the mammography equipment is not adjustable to radiographers' body anthropometrics (Costa et al., 2014). Therapeutic radiographers are also prone to adopt awkward postures during patient positioning (Griffin, 2018).

The manipulation of obese and elderly patients can promote or aggravated muscular disorders due to the increase load and lack of patient participation (Augner & Kaiser, 2019; European Occupational Safety and Health Administration, 2020; Griffin, 2018). High exposure to physical

load was also identified in emergency rooms, having plain and mobile radiography as main responsible for back and upper limbs discomfort (Kumar et al., 2004a). The physical effort required during mobilization of the X-ray tube and patient positioning is evident in both conventional radiography modalities (Bright Ofori-Manteaw et al., 2015). Sonographers also apply force to hold the transducer when scanning patients and the pressure required combined to the arm abduction at the same time can induce discomfort and pain in the dominant shoulder and wrist/hand (Fisher, 2015; Tinetti & Thoirs, 2019).

The static work may promote pain, numbness and tingling in different anatomical regions (Kim & Roh, 2014). Prolonged static position was particularly observed and problematic in CT and MRI (Daniel et al., 2018) and sonography (Fisher, 2015; Lamar, 2004; Tinetti & Thoirs, 2019).

Another risk factors for developing musculoskeletal injuries in radiographers are the repetitive movements and repetitive tasks over long periods observed in several modalities namely mammography, ultrasound and radiotherapy (Costa et al., 2014; Fisher, 2015; Kim & Roh, 2014; Siegal et al., 2010).

Nonergonomic working conditions as poor lightning, uncomfortable seats, narrow examination rooms and poor maintenance of equipment may be a contributor for high prevalence of injuries in radiographers context (Bright Ofori-Manteaw et al., 2015). Equipment in mammography was found to contribute to WRMSDs in radiographers since the design do not allow to work ergonomically during the patient positioning (Cernean et al., 2017). As well, ultrasound equipment design, specially transducer holding have a major influence in wrist disorders development (Tinetti & Thoirs, 2019). The need of manufacturer contribution was already highlighted to improve equipment design and allow an ergonomic practice (Cernean et al., 2017).

The organizational and psychological factors also seem to be important contributors of WRMSDs in radiographers (Augner & Kaiser, 2019; Griffin, 2018; Kumar et al., 2004b). Some studies showed that work was considered stressful by diagnostic radiographers (Arvidsson et al., 2016; Augner & Kaiser, 2019). One reason that may explain this stress is the lack of control over the workflow and workload (Kumar et al., 2004b). The studies carried out on radiotherapy showed that radiographers perceived psychosocial stresses in their work due to the high mental demands, untidy workflow, high workload, staff shortage and reduce break time (Griffin, 2018). When this happens, radiographers were frequently tired, they felt physical and mental fatigue, which can lead to errors in their practice (Bright Ofori-Manteaw et al., 2015), showing that psychosocial risk factors impact physical well-being (Griffin, 2018; Lorusso et al., 2007).

The association between individual characteristics and WRMSDs exists, and it varies in ergonomics and WRMSDs epidemiological research. For instance, none individual factors

(e.g., gender, BMI, smoking) was found to be correlated to radiographers' disorders, except age (Kumar et al., 2004a; Lorusso et al., 2007), while female gender was identified as being a risk factor in some related sonographers studies (Tinetti & Thoirs, 2019). However, controversies also exist regarding the influence of age in the development of WRMSDs within sonographers' group. The majority of results showed that age increases the risk, while other studies showed an increase of complaints in youngers sonographers (Tinetti & Thoirs, 2019). Additional factors, as BMI and smoker status, were associate with injuries in therapeutic radiographers (Hanania et al., 2020).

According to body region, the risk factors may differ, as for neck and shoulder, the pain was mainly associated with a high workload, while neck pain was associated with poor physical activity (Lorusso et al., 2007) and the backpain with age and physical condition (*Exploration of Self-Reported Work-Related Musculoskeletal Injuries among Radiographers & Radiation Therapists*, n.d.).

Additionally to individual characteristics above mentioned, professional background characteristics such as work percentage and years of experience were recognized to be related to MSDs likelihood (Kumar et al., 2004a; Lorusso et al., 2007). Available workforce is also important to consider, since staff shortage involves an increased workload leading to an increased risk of WRMSDs (Alhasan et al., 2014). The last WRMSDs contributors identified were long working hours and work time allocation having a significant impact on radiographers health (Daniel et al., 2018; Hulls et al., 2018; Pallotta & Roberts, 2017).

2.4 SUMMARY AND RESEARCH QUESTIONS

While quality of care and patient safety have been a national and international priority, the health and safety of healthcare professionals including radiographers has received less attention. Nevertheless, it has been shown that these two issues are closely linked (Ballinger et al., 2008; Sousa Uva & Serranheira, 2014).

Among work-related disorders and injuries threatening radiographers' health and safety the musculoskeletal disorders are the frequently identified. Indeed, medical imaging departments are a complex environment with a work that involves significant physical and mental demands affecting the safety and health of the radiographers (Augner & Kaiser, 2019; Kumar et al., 2003; Lorusso et al., 2007).

The value of this study to the radiographers is to aware stakeholders and policy makers about musculoskeletal health status of radiographers of Western Switzerland and identify risk factors related to WRMSDs symptoms, to facilitate a better cooperation between all actors to improve

departments and equipment design and to elaborate prevention strategies to reduce WRMSDs symptoms. Several research questions were identified to guide the study:

1. What is the prevalence of WRMSDs symptoms and the most affected anatomical regions?
2. What is the severity of WRMSDs symptoms as pain intensity and frequency that may be related to absenteeism?
3. Are the WRMSDs symptoms different for the three fields of radiographers' activity?
4. Which associations exists between symptoms and the risk factors (ergonomic, physical, organizational/psychosocial, and individual characteristics) related to WRMSDs?
5. What are the tasks and activities performed by radiographers during bedside chest plain radiography conducting to awkward postures according to European Standards?
6. Do the anthropometric differences between radiographers influence their postures performing bedside chest plain radiography?

3 METHODOLOGY

The structure of this chapter is organized in 4 sections: ethical considerations and data protection; study design and methodological approaches; characterization of the WRMSDs symptoms in radiographers; characterization of the radiographers' postures.

3.1 ETHICAL CONSIDERATIONS AND DATA PROTECTION

The research project was submitted to 2 Ethics Commissions (EC): SwissEthics of Canton of Vaud (Reference: 2020-011774, Annex I) and the EC of Centre Hospitalier Universitaire Vaudois (CHUV). Both submissions were accepted, and participants' consent was obtained for each phase of the study. The data was confidential and only accessible to authorized persons within the research project's scope. On the report and other project documents, participants were identified by a unique participant number avoiding their identification. All data were encrypted and stored in a protected folder on secured computer and regularly recorded on the servers of Haute Ecole de Santé du Canton de Vaud (HESAV), according to article 5 of the Human Research Ordinance (Ordinance on human research with the exception of clinical trials of 20 September 2013).

3.2 STUDY DESIGN AND METHODOLOGICAL APPROACHES

This study aims to characterize WRMSDs symptoms among radiographers of Western Switzerland and the postures assumed during bedside chest radiography. Therefore, a cross-sectional study was conducted to assess WRMSDs' symptoms prevalence, severity, risks factors and a postural assessment.

Ergonomic methods considering the contribution of risk factors have been developed to assess WRMSDs (David, 2005). One of the methods is self-administered surveys used to characterize WRMSDs symptoms (first aim corresponding to phase I). The observation methods are also useful to characterize the postures, for instance during equipment handling and patient positioning (second aim corresponding to phase II). The combination of both methods has already been used in previous studies (Acaröz Candan, Sahin, & Akoğlu, 2019).

3.3 CHARACTERIZATION OF THE WRMSDS SYMPTOMS IN RADIOGRAPHERS

3.3.1 Participants' sampling

The population considered in this study was all radiographers of western Switzerland currently working in clinical practice and actively employed during the last 12-months. An invitation containing the survey's link was emailed to the chief-radiographers' members of "Collège des Chefs TRM" (CCTRM)[1] and to HESAV clinical practice partners asking them to transfer to their collaborators. Other recruitment methods were used, namely social network communications channels (e.g., LinkedIn, Facebook) and the radiographers' Swiss professional association. Reminder emails and posts on social network were used within this period to encourage radiographers to complete the survey. The data collection was carried out between September 7th and October 31st, 2020.

3.3.2 Survey design, testing and application

A survey (Appendix I) was designed to characterize WRMSDs symptoms by identifying the prevalence, severity and associated risk factors. An enclosure letter was used to inform participants of the voluntary nature of participation, the purpose and the conditions of

[1] CCTRM is a group of 33 chief-radiographers involved in the evolution of radiology and the profession by promoting training, taking political positions and defending the interests of radiographers.

participation in the study (Appendix II). Prior to its distribution, the survey was tested in a sample of 12 radiographers (4 radiographers per field of activity) to ensure clarity of wording, the functionality, and to assess the survey length. The suggestions, when relevant, were incorporated and the estimated time to complete the survey varied between 10 to 20 minutes.

The final survey was distributed by using the LimeSurvey software (version 3.20.1) and it was composed by 102 questions organized into 6 topics: A. Individual factors; B. Professional background factors; C. Self-reported WRMSDs; D. Ergonomic and physical factors; E. Organizational and psychosocial factors; F. Remarks and comments.

Sections A, B, D, E assessing WRMSDSs' risk factors were based on existing questionnaires and literature (Serranheira, Cotrim, Rodrigues, Nunes, & Sousa-Uva, 2012) and exploratory variables were added to complete the survey (e.g., shifts, type of patients, working modalities). Section C assess WRMSDs symptoms presence and severity based on Nordic Musculoskeletal Questionnaires (NMQ) and section F offered the opportunity to participants to make comments. According to the nature of variables explored, closed and open-ended questions were used.

Participant's characteristics

Participants were characterized through 17 questions (sections A. Individual factors, and B. Professional background factors) namely: gender, date of birth, weight, height, general health, sports activity, tobacco, alcohol and energy drinks consummation, use of pain medication, medical consultations, rehabilitation treatments, present diseases/health problems and self-reported MSDs. Thirteen questions enquired work characteristics (years of practice, professional function, years working in the current in the institution, type of institution, work percentage, shift type, imaging modalities practiced, working days per imaging modality) due to its impact on WRMSDs development (Daniel et al., 2018; Eslick & Raj, 2002; Hulls et al., 2018; Kumar et al., 2004b). New variables were created from individual characteristics raw data as "age" from the "date of birth", "Body Mass Index (BMI)" from "height" and "weight" variables. Radiographers' functions allowed the definition of radiographers' practice as "radiographers" or "radiographers and other function(s)". Other categories were grouped (e.g., frequency of shifts was grouped into two categories: "Never/Sometimes" and "Often/All the time" and general health status in "Very good/Good" and "Very bad/Bad/Moderate") in order to meet the needs of statistical analysis.

Self-report WRMSDs symptoms

The Nordic Musculoskeletal Questionnaire is worldwide applied to detect and analyze musculoskeletal symptoms, especially in the healthcare sector (López-Aragón et al., 2017) and facilitates comparison of the results of different studies (Kuorinka et al., 1987; López-

Aragón et al., 2017). In this research project, the self-reported WRMSDs symptoms section was constructed based on a French version of NMQ already validated in 2 French studies cited by Descatha et al., 2010. The NMQ allows the WRMSDs self-reporting by indicating if pain and/or discomfort are present in neck, upper back, lower back, shoulder(s), elbow, wrist(s)/hand(s), hip(s)/thigh(s), knee(s), or ankle(s)/feet within the last 12 months and the last 7 days (Forcier et al., 2001; Kuorinka et al., 1987).

Wording adaptations were tailored to the context of radiographers and new questions were added about severity (e.g., work absence, length of work absence in the last 12 months), pain intensity (Numeric Pain Rating Scale[2]) and pain frequency of WRMSDs symptoms in the last 7 days (Mesquita et al., 2010; Nawrocka et al., 2014; Serranheira, Cotrim, Rodrigues, Nunes, & de Sousa Uva, 2012). Fourteen additional questions were designed to identify the most affected body region by performed imaging modality.

Ergonomic and physical risk factors

The ergonomic risk factors were assessed by one question of 5 statements covering awkward posture adopted, use of force, prolonged static position, repetitive movements, and long or numerous reaches. The following question contain 7 statements about the work environment including radiological equipment, namely physical environment, service layout, workspace, radiological equipment, radiological accessories, IT equipment, and furniture. Both questions were rated with a 4-point Likert scale, one for frequency (ergonomic factors), and the other for adequacy (physical factors). Data management was carried out to assign numbers to anchor terms. For statistical analysis, responses were grouped in “Never/Sometimes”, “Often/Always” or “Totally/Mostly inadequate”, “Mostly/Totally adequate” and “Don’t know/Not applicable” according to the item assessed.

Organizational/psychosocial risk factors

The organizational/psychosocial dimension was assessed through 8statements: work pace, time to complete the tasks, requirement of full attention, autonomy, quality of interactions with the hierarchy, colleagues, and other healthcare workers, satisfaction at work, and anxiety/stress was also assessed. Each statement was rated by a 4-points Likert scale indicating the agreement with the statement, and anchor terms were labelled with numbers

[2] Numeric Pain Rating Scale (NPRS) is an 11-points scale ranging from 0 to 10, 0 being no pain and 10 being extremely intense pain (Krebs et al., 2007)

and regrouped in 2 categories (“Totally/Mostly disagree” and “Mostly/Totally agree”) for data analysis.

3.3.3 Data analysis

Only completed surveys were analyzed. The principal dependents variables were WRMSDs symptoms presence in the previous 12 months and 7 days, in nine anatomical regions (dichotomous variable).

According to the nature of variables adequate descriptive were used to perform data analysis. Descriptive statistics were mainly used to describe participants characteristics (e.g., age, gender, years of experience), prevalence and severity of WRMSDs (WRMSDs rates, work absence, pain intensity and frequency). Quantitative variables were presented with mean, and standard deviation (SD) (e.g., age, year of experience) while qualitative variables were analyzed with modal value, median and contingency tables (e.g., gender, general health status, smoker status). In this study, the 4-point Likert scales were considered as ordinal data (Sullivan & Artino, 2013).

The chi-square test and exact Fisher test were used to explore associations between WRMSDs symptoms by anatomical regions, participants characteristics and work-related variables (detailed in Table 11, Appendix III). The associative analysis was performed for WRMSDs symptoms in the previous 12 months and 7 days separately. Odds ratios (OR) and 95% confidence intervals (CI) were reported compared to a reference group. The level of significance considered for the statistical analysis is 0.05. Data management and analysis were carried out with Stata, version 16.0 (StataCorp LP, College Station, Texas) and Microsoft® Excel (version. 16.43).

3.4 CHARACTERIZATION OF THE RADIOGRAPHERS’ POSTURES

3.4.1 Participants’ sampling

The targeted population was the diagnostic radiographers currently working in conventional radiology at CHUV and practicing bedside chest examinations for, at least, one year. Radiographers suffering from chronic or acute disease or being pregnant at the time of the study were excluded. For the simulations, two radiographers with extreme heights (shorter and taller) and a third radiographer with medium height were identified with the help of the conventional radiography chief. A fourth radiographer (weight ≥ 80 kg) was invited to simulate a passive patient. The fourth radiographers were personally contacted to obtain their participation agreement with an information and consent form (Appendix IV).

3.4.2 Observational methods

This phase intended to characterize radiographers' postures regarding equipment manipulation and patient handling for bedside chest X-ray examinations. To characterize the radiographers' postures, the prescribed and real work[3] needed to be described. The prescribed work was defined through an internal document of CHUV (*Conceptualisation prise en charge d'un patient au DIAG*, 2020), while the real work was identified through a sequential observation of the radiographers in clinical context without the participation of the observer. Additional non-participative observations were undertaken to collect the time spent per key activity of patient care in a case report form (Appendix V). The postures were also observed using graphical representations (Figure 12, Annex II) (Hellig et al., 2018). These observations took place between October 5th and 30th during different days and times to have an overview of the practice. Due to the presence of patients in real practice, filming was impossible and simulations were required (Costa et al., 2014) using the data collected during observations to ensure the similarity between the simulations and clinical activity. The simulations were performed with a radiography device from Philips (Philips Bucky Diagnost TH X-ray, Phillips Healthcare, Guildford, United-Kingdom). Chest X-ray examinations are generally performed by two radiographers, one to position the detector and manipulate the X-ray tube (designated as "performing radiographer"), and the other to handle the patient (called "helping radiographer"). All the permutations of heights and radiographers' roles were simulated, resulting in six scenarios. The simulations were recorded using photogrammetry methods to assess postural variations of the main body segments (head/neck, upper arm, and trunk) according to Kapitaniak et al. method (2001). Three cameras (one camera Canon EOS 90D and two cameras Canon EOS 1300D, Tokyo, Japan) were placed in order to record simultaneously posterior and lateral views of radiographers. The videos were visualized by the observer and the most demanding and/or prolonged postures were selected by two raters. The main body angles of observed body segments were measured with a dedicated software (Kinovea, version 0.8.15).

[3] Prescribed work represents the tasks expected from the worker and is defined by the work organization. Real work represents the application of the prescribed work; what is actually done by workers (activities) (Maulini, 2010)

3.4.3 Data analysis

The data collected during the observation was described. The joint angles measured in simulated situations were classified into three categories according to European Standards (EN 1005-4:2005 + A1:2008): “acceptable”, “conditionally acceptable”, and “not acceptable” (Table 1). These standards aim to improve the interaction between man and machine to reduce health risks (British Standard, 2018).

Table 1 - References values for postural assessment (European Standard BS EN 1005-4:2005 + A1:2008).

	References values		
Body segments	Acceptable	Conditionally acceptable	Not acceptable
Head/neck upward/downward bending	0° to 40°		< 0° or > 40°
Trunk forward/ backward bending	0° to 20°	< 0° or 20° to 60°	> 60°
Upper arm flexion/extension	0° to 20°	20° to 60°	< 0° or > 60°

4 RESULTS

This section presents the response rate and participants characteristics. The following sub chapters were organized accordingly to the aims of the study: i) characterization of WRMSDs symptoms in radiographer and ii) characterization of the radiographers’ postures.

4.1 CHARACTERIZATION OF WRMSDS SYMPTOMS IN RADIOGRAPHERS

4.1.1 Response rate and participants’ characteristics of survey

A total of 437 (out of 1’952 estimated radiographers[4]) fulfilled the questionnaire which means an estimated response rate of 22.39%. However, 78 were excluded because they did not meet the inclusion criteria (working in the field during the last 12 months), being analyzed a total of 359.

The participants mean age was 40±11 years ranging from 22 to 65 years old, having a normal weight with a mean BMI of 23.8±2.6 kg/m^2, and being predominantly women (64.3%). Out of

[4] Under the hypothesis that the number of radiographers increased linearly (+14.9% between 2010 and 2014 (Swiss conference of cantonal health directors & Swiss national health work organization, 2016), and that the proportions of western radiographers stayed stable (40.2%) (Lehmann et al., 2012), their number is estimated at 1,952 in Western Switzerland in 2020.

359 participants, 76.6% did not smoke, 97.8% used to drink alcohol in moderation[5], 56.3% had a reasonable consumption of caffeinated/energy drinks[6], and 64.1% practiced a regular physical activity[7] (Table 12, Appendix VI). The majority (85.0%) of the participants perceived their general health status as "good" or "very good", having a low (30.6%) consummation of medication in the last 7 days; 20.9% consulted a doctor more than 4 times a year and 12.0% underwent rehabilitation treatment during this study. Out of 339, 110 respondents had diseases or health disorders, of which 68.5% reported that existing health problems impact negatively their musculoskeletal system. The most frequent diseases/health problem were chronic affection of musculoskeletal system (n=46) and disorders affecting eyes and ears (n=34), cardiovascular system (n=23) and nervous system (n=22).

The mean professional experience was 15±12 years, with at least 11±10 years spent in the current institution. The participants worked mainly in full time (52.1%), with 98.3% working often during the day, 20.1% during nightshifts or being on-call (9.5%). The majority (68.3%) of radiographers did not have any other role than clinical practice with patients and 31.7% had "other activities" as chef, or referent for an imaging modality, research or radiation protection expert (Table 14, Appendix VI).

The highest proportion (73.8%) of radiographers worked in diagnostic and interventional radiology, 16.4% worked in radiotherapy and 9.8% in nuclear medicine. The diagnostic radiographers practiced at least 4 (over 6) imaging modalities, while nuclear medicine radiographers worked in 3 (over 3) and therapeutic radiographers in 2 (over 3). In diagnostic, most radiographers practiced conventional radiology (n=242), followed by CT (n=192), MRI (n=152), ultrasound (n=99), interventional radiology (n=96) and mammography (n=95). In nuclear medicine, radiographers equally worked at Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET) (n=34), while a smallest number worked in laboratories (n=24). Most therapeutic radiographers worked at the treatment machine and performed CT/MRI simulation (respectively, n=55 and n=41), while a minority worked as dosimetrist (n=23). Other activities (e.g., management, research, training,

[5] A moderate consumption of alcohol means up to one drink a day for women and up to 2 drinks a day for men (Addiction Suisse, 2013).

[6] A reasonable consumption of caffeinated/energy drinks means up to 2 drinks a day (Dépatement de la formation de la jeunesse et de la culture & Département social de la santé et de l'action sociale, 2018).

[7] Exercising regularly means 150 min/week of moderate physical activity or 75 min/week of strenuous physical activity (Organisation mondiale de la santé, n.d.).

expertise) were practiced by a high proportion of nuclear medicine radiographers (51.4%), in contrast to therapeutic (25.4%) and diagnostic (18.9%) radiographers (Table 15, Appendix VI).

Almost all participants worked in the public sector (74.9%), almost equally distributed in university (n=127) and non-university (n=142) institutions, while 25.1% worked in private or semi-private institutions (n=90) (Table 14, Appendix VI). In public institutions, radiographers provide care with high frequency to outpatients and inpatients almost equally (respectively 94.1% and 85.5%), in contrast with the private institutions (respectively, 97.8% against 31.1%).

Ergonomics and physical characteristics of workplace

The participants high scored (3 & 4) most of biomechanical statements meaning that radiographers needed to use physical force, working in static postures, doing repetitive movements, and making long/numerous reaches to perform their occupational activities. Only "working in awkward posture" was rated "2" meaning that the adoption of awkward postures was less frequent (Table 16, Appendix VI).

Regarding workplace environment (physical risk factors), the participants attributed "3" – "mostly adequate" – to all statements: physical environment, service layout, workspace, radiological equipment, accessories, IT equipment, and furniture (Table 16, Appendix VI).

Organizational/psychosocial characteristics of workplace

The mode obtained for 7 out of 9 statements about organizational/psychosocial risk factors was "3" & "4" indicating that these risk factors were mainly absent. Only 2 statements were negatively scored with "2" revealing that radiographers were subject to a high work pace and that their occupational tasks required their full attention. The results also showed organizational/psychosocial factors were scored similarly by radiographers working in the 3 radiological fields (Table 17, Appendix VI).

Survey remarks and comments

Participants left 48 remarks and general comments at the end of the survey, 13 of them described the high physical and psychological demands related to radiographers' occupational activity. Three of the participants reported the need of ergonomic education and patient-handling training in radiographers and 15 provided details regarding answered questions and symptoms. The remaining comments concerned positive feedbacks and positive incentives.

4.1.2 Prevalence and severity of WRMSDs symptoms

Based on the total of participants (n=359), 94.7% presented WRMSDs symptoms in the last 12 months, and 67.7% in the last 7 days (Figure 2). The main affected anatomical areas identified by radiographers in last 12 months were neck (73.0%), lower back (67.4%),

shoulders (55.7%) and upper back (44.9%) (Figure 2 and Table 18, Appendix VI). These results were similar for the 3 radiological fields (Table 18 and Table 19, Appendix VI).

In last 7 days, the regions predominantly reported as painful were neck (36.8%), lower back (35.7%), upper back (22.3%) and shoulders (21.7%) (Figure 2). The distribution of WRMSDs in the last 7 days was slightly different by radiological field. Amongst diagnostic radiographers, the most affected regions were neck, lower back and upper back, while for MN and RT radiographers were neck, lower back and shoulders (Table 19, Appendix VI).

The assessment of the severity of the symptoms revealed that 15.6% (56/359) had a work absence in the last 12 months mainly due to pain in the lower back region (6.7%), wrists/hands (2.8%) and upper back (2.8%) (Figure 2). The nuclear medicine radiographers having slightly more absenteeism (28.6%) than radiographers from other fields (DIR = 12.8%; RT = 20.3%). The duration of the absence varied from 2 to 202 days depending on the anatomical regions and radiological field. The average work absence length was 202 ± 154 days for elbows, 97 ± 129 days for shoulders, and 85 ± 118 days for neck problems. According to radiological field, the work absences were longer in diagnostic and interventional radiology (for any anatomical region) than in other fields (Table 20, Appendix VI).

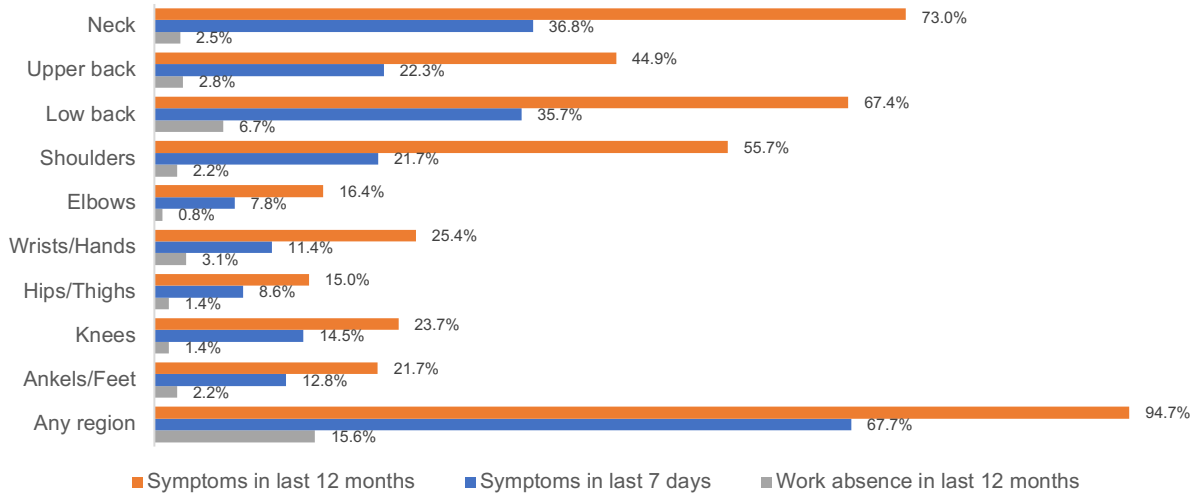


Figure 2 - WRMSDs symptom prevalence in radiographers during the last 12 months, last 7 days and work absence in last 12 months.

The analysis of musculoskeletal symptoms, in terms of pain intensity in last 7 days, revealed that 49.9% of the total participants (179/359) suffer from moderate or severe pain intensity[8].

[8] In the NPRS, mild pain corresponds to a pain score from 1 to 3, moderate pain corresponds to a pain score from 4 and 6, and severe pain corresponds to a pain score from 7 to 10.

Among symptomatic radiographers, the majority (from 50.0% to 80.0% depending on the anatomical regions and radiological field) have a peak of pain intensity from moderate to severe in the last 7 days (Figure 3). The pain intensity (median) was slightly higher in shoulders, wrists/hands and lower back, rather than in other anatomical regions. In diagnostic radiographers, the median pain was more intense in wrists/hands, while it was more intense in neck and shoulders in nuclear medicine radiographers, and in upper back, lower back and feet in therapeutic radiographers (Table 21, Appendix VI).

Concerning the disorder frequency in the previous 7 days, 40.9% of participants felt the symptoms in any anatomical region "often/every day"[9] in the last 7 days. Among symptomatic radiographers, this number reaches 76.1% of radiographers depending the on anatomical region. The anatomical regions most affected by the high frequency of pain were feet (76.1%), hands/wrists (65.9%), elbows (64.3%), hips/thighs (61.3%) and shoulders (51.3%) compared to other anatomical regions where the pain was "rarely/sometimes present"[10] (Figure 4). The high frequency of symptoms in ankles/feet and wrists/hands is common to radiographers from DIR, MN and RT (Table 22, Appendix IV).

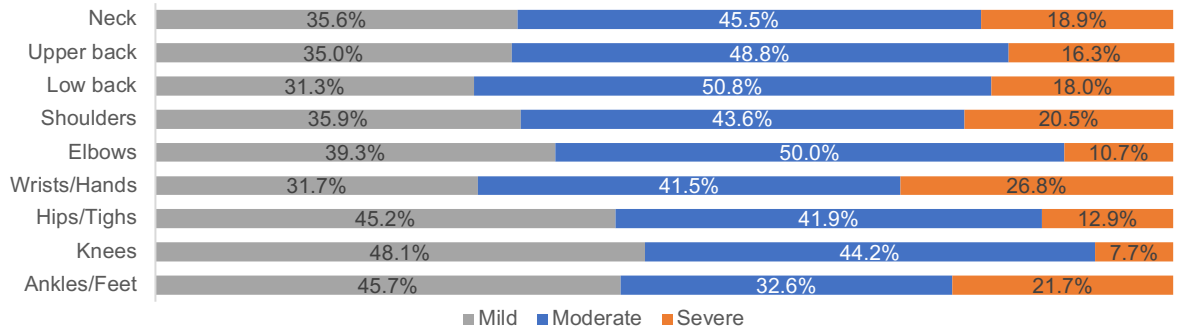


Figure 3 - Pain intensity (NPRS) in last 7 days in symptomatic radiographers (as a group) by anatomical region.

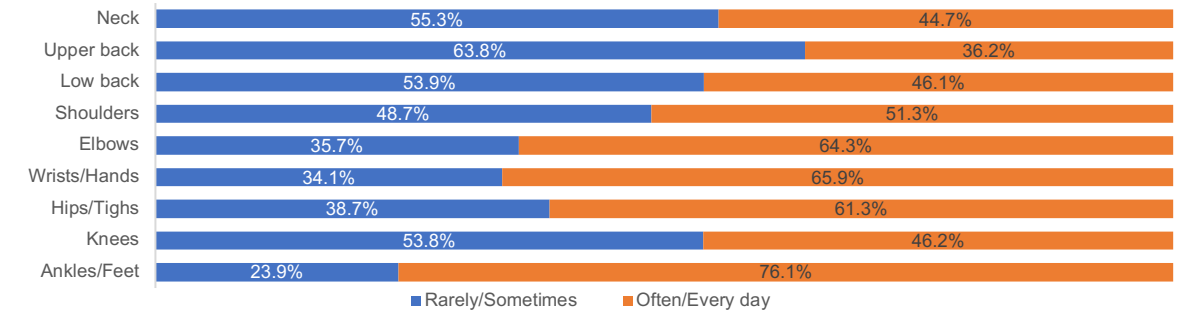


Figure 4 - Pain frequency in last 7 days in symptomatic radiographers (as a group) by anatomical region.

[9] (≥ 4 days per week)

[10] (≤ 3 days per week)

4.1.3 Associations between WRMSDs symptoms and risk factors

Lower back was reported as the most affected anatomical area by the 68.8% of the radiographers that self-associated WRMSDs symptoms with the modalities, except for laboratory activities where shoulders and wrists/hands were highlighted, and dosimetry and "other activities", both mainly affecting the neck.

In addition to these self-reported associations, statistical associative tests were conducted to highlight associations between WRMSDs symptoms and risk factors identified in the literature. Firstly, associative tests were performed to determine whether the radiological domain influenced the occurrence of WRMSDs symptoms by body regions. The result showed that there was no significant association between radiological fields and WRMSDs symptoms in previous 12 months and 7 days ($p>0.05$ in all anatomical region). Additionally, the risk of WRMSDs symptoms does not statically differ between radiological fields (Table 23 and Table 24, Appendix VII). Since no association could be statistically demonstrated, data were analyzed for radiographers as a group, and no distinction was made between radiographers' specialties in the associative analysis.

WRMSDs symptoms in the last 12 months and risk factors

Symptoms in the spine in the last 12 months

The symptoms in the spine were significantly associated with awkward postures, physical force, physical environment, service layout, workspace, radiological equipment, furniture, autonomy in professional activity, anxiety/stress feeling, satisfaction at work, gender, diseases or health disorders ($p<0.05$) resumed in Table 2, Table 3 and Table 4 (see detailed analyses in Table 25, Table 26 and Table 27, Appendix VII).

The chances of developing WRMSDs symptoms in the neck were significantly high (OR>2) for radiographers working frequently in awkward postures during occupational activities (2.15; 95% CI 1.33-3.49) and having previous diseases/health disorders (OR=2.22; 95% CI 1.26-3.92) (Table 2). The factors increasing the risk of upper back WRMSDs symptoms significantly (OR>2) were poor rapports with other radiographers (OR=4.83; 95% CI 1.31-17.88) and being unsatisfied with the professional activity (OR=2.16; 95% CI 1.16-4.03) (Table 3). Radiographers adopting frequently awkward postures and exerting frequently physical force to perform their occupational activity had a higher probability of having symptoms in lower back (respectively OR=2.86; 95% CI 1.78-4.58 and OR=2.18; 95% CI 1.30-3.65) (Table 4).

Table 2 - Resume of WRMSDs symptoms in the neck significantly associated with risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	2.15	1.33 - 3.49	0.001
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.91	1.13 - 3.25	0.015
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.82	0.99 - 3.34	0.050
Furniture	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.89	1.11 - 3.23	0.018
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.87	1.03 - 3.39	0.035
Gender	Men	1.00		
	Women	1.90	1.17 - 3.08	0.008
Diseases or health disorders	No	1.00		
	Yes	2.22	1.26 - 3.92	0.005

Table 3 - Resume of WRMSDs symptoms in the upper back significantly associated with risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.73	1.13 - 2.65	0.011
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.70	1.06 - 2.73	0.025
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	4.83	1.31 - 17.88	0.009
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.67	1.08 - 2.59	0.019
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.16	1.16 - 4.03	0.013

Table 4 - Resume of WRMSDs symptoms in the lower back significantly associated with risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	2.86	1.78 - 4.58	>0.001
Physical force	Never/Sometimes	1.00		
	Often/Always	2.18	1.30 - 3.65	0.002
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.93	1.01 - 3.69	0.042
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.80	1.11 - 2.91	0.016
Gender	Men	1.00		
	Women	1.60	1.01 - 2.53	0.043

Symptoms in upper and lower limbs in last 12 months

The symptoms in upper and lower limbs anatomical regions were present in a minority of participants (Figure 2), except for shoulders (55.7%). Variables showing significant associations with symptoms for shoulders were gender, age, diseases/health problems, awkward postures, physical environment, time to complete the volume of work, anxiety/stress, and work satisfaction ($p<0.05$) (Table 5). The chance of having WRMSDs in shoulders was

doubled for radiographers with 50-60 years, when compared to radiographers aged from 20 to 29 years (OR=2.28; 95% CI 1.15-4.49). Not being satisfied with work also increased the probability of developing WRMSDs in shoulders (OR=2.43; 95% CI 1.23-4.80) for the participants of this study (Table 5 with a detailed analysis presented in Table 28 to Table 33, Appendix VII).

Table 5 - Resume of WRMSDs symptoms in shoulders significantly associated with risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.80	1.18 - 2.76	0.006
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.67	1.06 - 2.62	0.025
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.60	1.04 - 2.44	0.030
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.85	1.18 - 2.89	0.006
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.43	1.23 - 4.80	0.008
Gender	Men	1.00		
	Women	1.70	1.09 - 2.64	0.017
Age	20-29 yo	1.00		
	30-39 yo	1.26*	0.71 - 2.25	
	40-49 yo	1.39*	0.72 - 2.66	
	50-59 yo	2.28	1.15 - 4.49	
	60 yo and more	2.51*	0.78 - 8.08	0.008
Diseases or health disorders	No	1.00		
	Yes	1.64	1.03 - 2.60	0.035

** Result not statically significant.*

WRMSDS symptoms in the last 7 days and risk factors

Symptoms in the spine in the last 7 days

The awkward postures, physical force, long/numerous reaches, physical environment, furniture, time to complete the volume of work, feeling anxiety/stress gender and previous diseases or health disorders were significant risk factors for the spine ($p<0.05$) (resumed Table 6, Table 7 and Table 8 with detailed analyses presented in Table 34, Table 35 and Table 36 , Appendix VII).

The effects were considered significantly important in neck for radiographers adopting frequently awkward postures (OR=2.01; 95% CI 1.21-3.34), exerting force frequently (OR=2.03; 95% CI 1.09-3.77) and women (OR=2.64; 95% CI 1.51-4.61) (Table 6). From the 3 risk factors influencing upper back symptoms, the inadequate physical environment and inadequate furniture showed to have a greater impact on the risk by increasing it more than twofold (respectively, OR=2.13; 95% CI 1.09-4.15 and OR=2.14; 95% CI 1.08-4.25) (Table 7). Same tendency observed for the lower back region, where "feeling anxiety/stress at work"

(OR=2.38; 95% CI 1.39-4.08) and "diseases/health disorders presence" (OR=2.39; 95% CI 1.35-4.25) had important impacts on the symptoms (OR>2) (Table 8).

Table 6 - Resume of WRMSDs symptoms in the neck significantly associated with risk factors (last 7 days).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	2.01	1.21 - 3.34	0.006
Physical force	Never/Sometimes	1.00		
	Often/Always	2.03	1.09 - 3.77	0.023
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.84	1.10 - 3.05	0.018
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.64	1.01 - 2.68	0.048
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.00	1.20 - 3.34	0.007
Gender	Men	1.00		
	Women	2.64	1.51 - 4.61	>0.001
Diseases or health disorders	No	1.00		
	Yes	1.80	1.07 - 3.02	0.025

Table 7 - Resume of WRMSDs symptoms in the upper back significantly associated with risk factors

Risk factors	Categories	OR	95% CI	P-value global test
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.13	1.09 - 4.15	0.023
Furniture	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.14	1.08 - 4.25	0.026
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.93	1.02 - 3.67	0.041

Table 8 - Resume of WRMSDs symptoms in the lower back significantly associated with risk factors (last 7 days).

Risk factors	Categories	OR	95% CI	P-value global test
Not feeling anxiety/stress	Totally/Mostly agree	1.00		0.001
	Totally/Mostly disagree	2.38	1.39 - 4.08	
Gender	Men	1.00		0.016
	Women	1.96	1.12 - 3.41	
Diseases or health disorders	No	1.00		
	Yes	2.39	1.35 - 4.25	0.002

Symptoms in upper and lower limbs in the last 7 days

The symptoms in upper and lower limbs were less relevant by their lower prevalence, except for the shoulders, having a prevalence close to spine anatomical regions. The results showed significant association between shoulders symptoms and awkward postures, repetitive movements, work pace, anxiety/stress, gender and diseases/health disorders as risk factors for high probability of WRMSDs (OR>2) (Table 9). A detailed analysis is presented from Table 37 to Table 42, Appendix VII.

Table 9 - Resume of WRMSDs symptoms in the shoulders significantly associated with risk factors (last 7 days).

Variables	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	2.46	1.31 - 4.61	0.004
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	2.20	1.18 - 4.07	0.010
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	3.41	1.10 - 10.63	0.024
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.11	1.16 - 3.82	0.012
Gender	Men	1.00		
	Women	2.19	1.11 - 4.29	0.020
Diseases or health disorders	No	1.00		
	Yes	2.56	1.39 - 4.73	0.002

4.2 CHARACTERIZATION OF THE RADIOGRAPHERS' POSTURES

4.2.1 Description of prescribed work and real work

A brief work analysis was undertaken to better understand the physical demands of radiographers' activities performing chest X-ray examinations. The patient care in conventional radiography context can be conceptualized in 4 phases corresponding to the prescribed work: "Analysis of prescription", "Room preparation", "Patient care" and "Analysis and closure of the X-ray exam" (*Conceptualisation prise en charge d'un patient au DIAG*, 2020). But to verify whether the prescribed work matches the real work, observations of practice were carried out. The collaboration between two radiographers was often required to perform this examination due to patients' incapacity to collaborate. The prescribed and real work were described below and summarized in Figure 5:

Analysis of examination prescription: Radiographers received an electronic request for X-ray examinations of inpatients. Once the medical indication of X-ray *(Medical indications)* and administrative data are analyzed and checked *(Administrative data)*, the patient is entered into the IT system, and the transport service is activated to drive the patient to the radiology department *(Administrative process)*. The request can also contain important information about the patient's weight, physical condition, their transportation (wheelchair or bed), and isolation precautions.

Room preparation: Radiographers place the detector in a protective sleeve to respect hygiene standards *(Preparation of radiological equipment)*. The patient is selected on the workstation, and the examination protocol (Thorax AP in bed) is chosen. Depending on the patient's body habitus, the adaptation of exposure parameters may be required *(Preparation of the workstation)*.

Patient care: Patient care begins with the presentation of the radiographer, followed by the identification of the patient and the explanation of the examination process *(Patient identification)*. Radiographers help the patient to lift the trunk *(Patient handling)* and one of the radiographers position the detector in the bed under the patient's back *(Detector positioning)*. The radiographers verify the detector's position to ensure that is correct *(Control detector position)*. The X-ray tube is centered, and collimation is adapted to the interest region *(X-ray tube manipulation)*.

Image acquisition: The radiographers return to the workstation room and observe the patient to ensure he/she does not move *(Patient observation)*. Standing behind the lead glass, one of the radiographers asks the patient to breathe in deeply and hold it before acquiring the chest radiography *(Patient instruction).*

Analysis and closure of the X-ray exam: The radiographers evaluate the quality of the acquired image to verify if it responds to the clinical needs *(Evaluation of image quality)*. Images with adequate quality are post-processed, if necessary, before being sent to the hospital's Picture archiving and communication system (PACS) *(Post-processing and sending of the images)*. Once the image sent, the tube is removed *(X-ray tube removal)*, and both radiographers lift the patient's trunk *(Patient handling)* to remove the detector (*Detector removal).* At the end of patient care, radiographers disinfect radiological equipment and reorganize the room *(Room tidying)*. Administrative procedures are undertaken for examination invoice and to transfer the patient to his/her room *(Administrative process).*

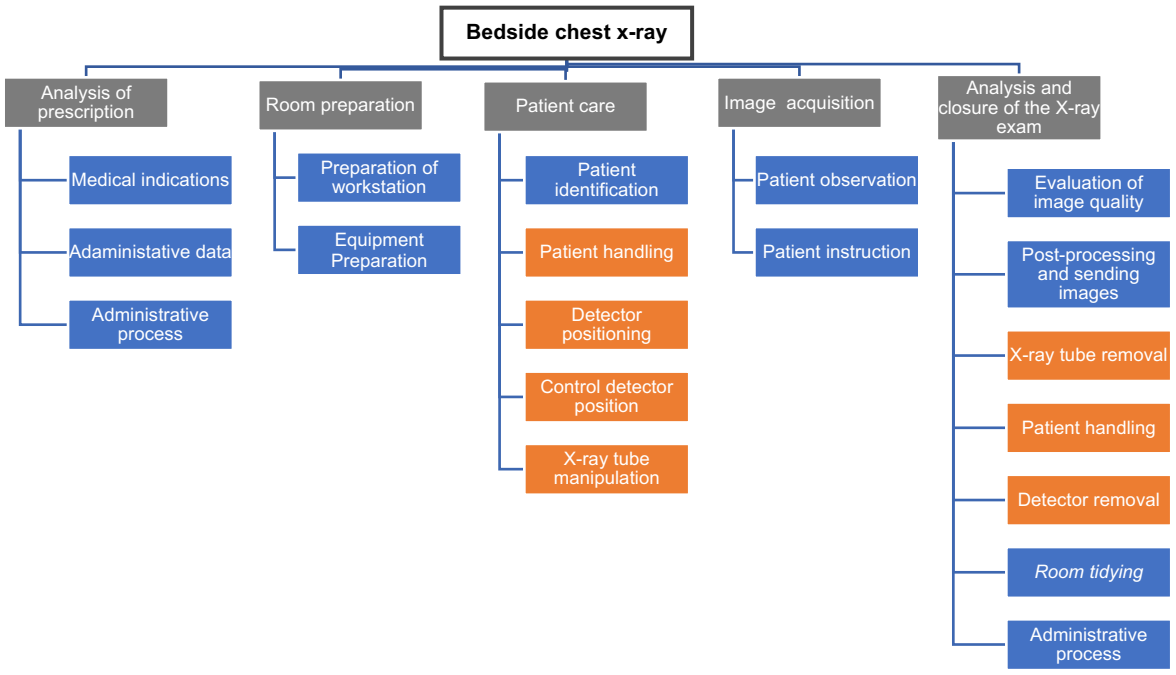


Figure 5 - Flow chart of prescribed (gray) and real (blue & orange) work performed during chest X-ray examinations for patient in bed on conventional radiography room.

The analysis focused on demanding tasks namely patient handling and radiological equipment manipulation (in orange Figure 5). The time taken for these tasks before X-ray acquisition varies from 32 to 57 seconds, while post-acquisition tasks were performed in 17 to 29 seconds. The total time ranged from 49 seconds to 1 minute and 21 seconds (Table 43, Appendix VII).

The helping radiographer lifts the patient to allow the performing radiographer to position and to remove the detector from patient's back. The trunk's position of helping radiographer during patient handling was flexed (20-40°) and as also the arms (30-60°) (Table 44, Appendix VIII). The performing radiographers assumed a flexion of the trunk (20-40°) and arms (30°) during the patient handling and detector positioning (Table 45, Appendix VIII). The posture adopted while controlling detector position does not differ between "helping" and "performing" radiographers, both slightly flexed the trunk (20°) and the arms (30-60°) to reach the detector and control its position (Table 44 and Table 45, Appendix VIII). The performing radiographer manipulated the X-ray tube by arm flexion (60-120°) and maintaining the trunk straight (0°) (Table 45, Appendix VIII). After the image acquisition, the helping radiographer handled the patient adopting the same position as before detector as also the performing radiographer removing the detector (Table 44 and Table 45, Appendix VIII).

4.2.2 Measurements and classification of joints angles

Three radiographers were asked to simulate a chest X-rays performed in a bed at a convectional radiography room. Six scenarios were played according to the radiographers' anthropomorphic characteristics and radiographer roles (performing/helping). The radiographers' height was codded as follows: Rad 1 for the tallest radiographer (198 cm); Rad 2 for the medium radiographer (176 cm) and Rad 3 for the shortest radiographer (155 cm).

Scenario 1 - Taller radiographer (performer) & shorter radiographer (helper)

In this scenario, assumed postures with a "not acceptable" component according to the European Norm are illustrated in Figure 6.

Preparation to position the detector under the patient's back. The performing and helping radiographers prepared to lift the patient by performing a slight trunk flexion. The performing radiographer slightly bent downward the head/neck, while the helper tended to extend it. Both radiographers' visible arms assumed a slight flexion by placing the forearm under patient's back. The trunks (Rad 1=48°; Rad 3=42°) and arms angles (Rad 1=20°; Rad 3=38°) were classified "conditionally acceptable" according to the European standard for both. The flexion of the head/neck of the performing radiographer was classified as "acceptable" (11°), and the

neck extension of the helping radiographer was “not acceptable” (Table 46 and Figure 13, Appendix VIII).

Patient handling to position the detector under the patient’s back. During the exertion of force for this activity, the trunk flexion of the performing radiographer was more critical than in the helping radiographer since both radiographers collaborated to lift the patient. The arms supporting the patient’s back remained in a neutral position in the performing radiographer and flexed in the helping radiographer. Performing radiographer slid the detector under the patient keeping the same posture as before. The trunk angle (37°) position of the performing radiographer was classified as “conditionally acceptable”, while the upper arm (0°) and head/neck position (10°) were rated as “acceptable”. The helping radiographer trunk angle (20°) was considered as “acceptable” according to the European Norm, contrary to flexion of arm classified as “conditionally acceptable” (29°). The head/neck in the helping radiographer was not measurable due to a slight rotation (Table 46 and Figure 13, Appendix VIII).

Control of detector position. during this task the performing radiographer bent the trunk to overview the detector position. Both arms were flexed to verify and reposition when necessary. The trunk (44°) and arm flexion (40°) were rated as “conditionally acceptable” while the head/neck was classified as “acceptable” (0°) (Table 46 and Figure 13, Appendix VIII).

X-ray tube positioning required from the performing radiographer to adopt an orthostatic posture with the trunk aligned with the mid-sagittal plane of the body. According to the European Norm, only the posture of the trunk was “acceptable”, the head/neck (22°) and arms angles (52°) were classified as “conditionally acceptable” (Table 46 and Figure 13, Appendix VIII).

Preparation to remove the detector from under the patient’s back is similar to the detector positioning under the back, obliging both radiographers to bend the trunk and flex the arms to place their hands under the patient’s back and prepare to exert force to lift the patient. The head/neck of preforming radiographer stayed aligned with the rest of the vertebral spine in contrast to helping radiographer, who extended her head/neck during this procedure. The angles of the trunk (Rad 1=48°; Rad 3= 50°) and arms (Rad 1=28°; Rad 3= 36°) were considered as “conditionally acceptable” for both radiographers. The segment of head/neck in performing radiographer was “acceptable” (0°), while the helping radiographer adopted a head/neck extension (-24°) considered as “not acceptable” (Table 46 and Figure 13, Appendix VIII).

Patient handling to remove the detector from under the patient’s back required a slightly flexion of the trunk from both radiographers. The arm pulling the patient was in a neutral position (0°) for the performing radiographer and the helping radiographer arm was in flexion. The

performing radiographer slightly bent downward the head/neck segment, while the helping radiographer has extended. The angles formed by trunk (30°), arms (0°) and the head/neck (16°) segments in performing radiographer were considered “acceptable”. Helping radiographer adopted postures classified as “conditionally acceptable” for trunk (31°) and arms (28°), while head/neck was not measurable (Table 46 and Figure 13, Appendix VIII).

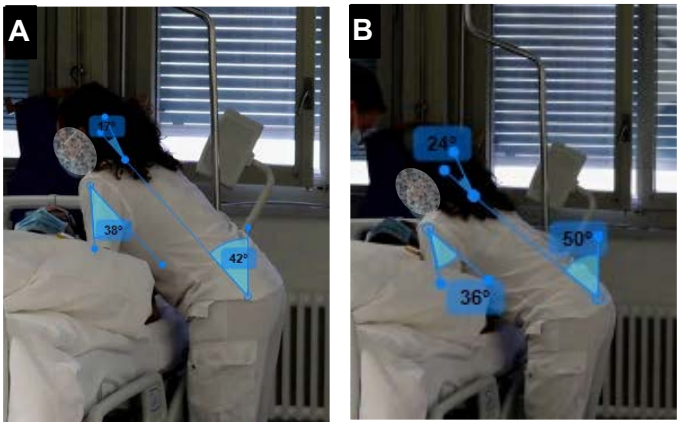


Figure 6 - “Not acceptable” postures assumed by the shorter radiographers (helper) during bedside chest X-ray examination in scenario 1: a) during the preparation to position the detector under the patient's back; b) during the preparation to remove the detector from under the patient's back.

Scenario 2 - Taller radiographer (performer) & medium radiographer (helper)

In this scenario, assumed postures with an “not acceptable” component according to the European Norm are illustrated in Figure 7.

Preparation to position the detector under the patient’s back demanded from the helping radiographer to take the patient by the shoulders. This action required the radiographer to bend over the patient and flexed the arms. The performing radiographer placed the detector along the patient’s body and flexed the visible arm to help to lift the patient. The trunk and head/neck flexion were required to exert force and have an overview of the patient. The assessment of radiographers’ postures revealed that trunks’ postures (Rad 1=40°; Rad 2=47°) were “conditionally acceptable”. The upper arm position in performing radiographer (21°) was “conditionally acceptable”, while the arm’s flexion (87°) of the helping radiographer was “not acceptable”. The flexion of head/neck (18°) for the performing radiographer was considered as “acceptable” while the helping radiographer’s head/neck angle was not visible (Table 47 and Figure 14, Appendix VIII).

Patient handling to position the detector under the patient’s back required force to the helping radiographer to lift the patient by the shoulders. The performing radiographer slightly helped to lift the patient by holding the arm. The patient handling required force translated by straightening radiographers’ trunk and arms’ flexion. The heads/necks remained flexed in both radiographers allowing to have an overview of the patient. According to the European Norm,

in patient handling, the performing radiographer's trunk (32°) assumed a "conditionally acceptable" posture, while arm (0°) and head/neck (17°) were classified as "acceptable" postures. The helping radiographer adopted "acceptable" postures regarding the trunk (15°) and head/neck (28°), but "not acceptable" for the upper arm flexion (65°) (Table 47 and Figure 14, Appendix VIII).

Positioning the detector under the patient's back was done by the performing radiographer while helping the helping radiographer to lift the patient. During this movement, the performing radiographer increased trunk's flexion to slide the detector under the patient's back with his left hand. The evaluation of the radiographer's posture demonstrated the arm (0°) was in a "acceptable" position, but the trunk (45°) was "conditionally acceptable" (Table 47 and Figure 14, Appendix VIII).

Control of detector position was checked by the performing radiographer while the trunk and arms were flexed in order to reach the detector. The alignment of the head/neck with the trunk provided a sufficient view of patient's and detector's position. The trunk (43°) and arms (40°) angles were both classified as "conditionally acceptable" and head/neck (0°) was determined as "acceptable" (Table 47 and Figure 14, Appendix VIII).

X-ray tube positioning was responsibility of the performing radiographer. The trunk was aligned with the mid-sagittal plane of the body, the arms were flexed to reach the tube and the head/neck was also flexed to centering the patient's chest. The posture assessment revealed that the radiographer adopted an "acceptable" trunk (0°) and head/neck (21°) angles. The arm posture (56°) to position the tube was "conditionally acceptable" (Table 47 and Figure 14, Appendix VIII).

Preparation to remove the detector from under the patient's back implied a trunk flexion of both radiographers. The helping radiographer positioned her hands under the patient's shoulders by flexing the upper arms. The performing radiographer put his right forearm under the patient to help lifting the patient by flexing the right upper arm. The left hand was placed on the detector to remove it. The head/neck was slightly flexed over the patient and both trunks' angles (Rad 1=44°; Rad 2=53°) were classified as "conditionally acceptable". The arm position adopted by the performing radiographer (25°) was "conditionally acceptable" compared to the arm position of the helping radiographer (93°), which was classified as "not acceptable". Performing radiographer's head/neck position (Rad 1=8°) was considered as "acceptable", while head/neck posture of helping radiographer was not measurable (Table 47 and Figure 14, Appendix VIII).

Patient handling to remove the detector from under the patient's back required a lift of the patients by the shoulders performed by the helping radiographer. The left arms and trunk

angles were reduced due to the exertion of force compared to the previous action. The performing radiographer also participated in the patient handling by lifting the patient with the right arm and removing the detector with the left arm. Both radiographers flexed their heads forward to observe the patient and detector removal. According to the European norm, the trunk (29°) and arm (23°) of the performing radiographer were in “conditionally acceptable” postures. The trunk position of the helping radiographer (18°) was classified as “acceptable”, but the arm angle (66°) was rated as “not acceptable” posture. Both radiographers' neck flexion (Rad 1= 6°; Rad 2=9°) were “acceptable” (Table 47 and Figure 14, Appendix VIII).

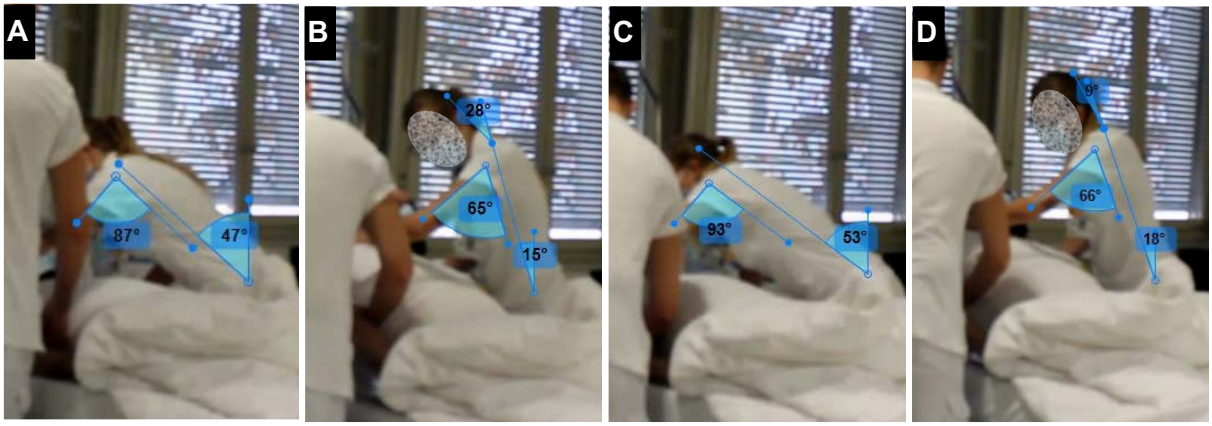


Figure 7 - “Not acceptable” postures assumed by the medium radiographer (helper) during bedside chest X-ray examination in scenario 2: a) during the preparation to position the detector under the patient's back; b) during the patient handling to position the detector under the patient’s back; c) during the preparation to remove the detector from under the patient’s back; d) during the patient handling to remove the detector from under the patient’s back.

Scenario 3 - Medium radiographer (performer) & taller radiographer (helper)

In this scenario, assumed postures with an “not acceptable” component according to the European Norm are illustrated in Figure 8.

Preparation to position the detector under the patient’s back, in this scenario, the helping radiographer prepared to lift the patient alone. The trunk and the head/neck were in flexion to hold the patient by the shoulders and to observe the patient. The performing radiographer prepared to slide the detector under the patient by positioning it next to the patient’s arm and maintaining the trunk slightly flexed. The right upper arm was in a neutral position, and the head/neck was flexed to observe the patient. According to European Norm, the performing radiographer’s postures of the trunk (9°) upper arm position (0°) and head/neck (14°) were classified as “acceptable”. The helping radiographer adopted a head/neck posture (19°) “acceptable” but the trunk position (37°) was rated as “conditionally acceptable” and the arm flexion (78°) was “not acceptable” (Table 48 and Figure 15, Appendix VIII).

Patient handling to position the detector under the patient’s back was performed by the helping radiographer alone by lifting the patient so that the detector could be placed under the chest.

The head/neck and trunk were slightly bent (23°) over the patient to push the patient and to maintain him lifted and the arms were flexed (60°) being classified as “conditionally acceptable” postures. The head/neck position (18°) was considered “acceptable” (Table 48 and Figure 15, Appendix VIII).

Positioning the detector under the patient’s back required the performing radiographer to bend the trunk downward and assumed arm flexion. The head/neck was maintained in a neutral position (aligned with the trunk) allowing the observation of the patient and detector positioning. The trunk (41°) and arm (34°) flexions assumed were “conditionally acceptable”, while the posture of head/neck (0°) was considered as “acceptable” (Table 48 and Figure 15, Appendix VIII).

Control of detector position was done by the performing radiographer to ensure that the patient and the detector are well-positioned. The trunk (32°) and head/neck (16°) were flexed to provide an overview of the patient and detector position. The arms performed a flexion (37°) to reach and manipulate the detector. The trunk and arm flexions were classified as “conditionally acceptable”, while the head/neck was “acceptable” (Table 48 and Figure 15, Appendix VIII).

Manipulation of the X-ray tube was performed by the helping radiographer, in a first moment, to pass it to the performing radiographer that was orthostatic while waiting. The trunk, arm and head/neck segments of performing radiographer were aligned with the body's mid-sagittal plane in a neutral position. All the measured angles (0°) were considered as “acceptable” in this situation (Table 48 and Figure 15, Appendix VIII).

X-ray tube positioning was done by the performing radiographer by flexing the upper arms to reach the equipment. The slight tilt of the X-ray tube demanded the radiographer an extending of the head/neck and trunk. The trunk flexion (0°) was rated, respectively “conditionally acceptable”, while the arm flexion (83°) and extended posture of head/neck (-18°) were classified as “not acceptable” (Table 48 and Figure 15, Appendix VIII).

Preparation to remove the detector from under the patient’s back was realized by both radiographers. The performing radiographer by placing the hands on the detector and removing it with a flexion of the trunk and arms. The head/neck posture (aligned with the trunk) allowed the observation the patient and the helping radiographer. The helping radiographer placed the hands-on patient’s shoulders to lift and observe him at the same time, which required a flexion of the trunk, arms and head/neck. The angles measured in the performing radiographer were considered as “acceptable” for head/neck (0°), but “conditionally acceptable” for trunk (39°) and arms (45°). The assessment of the head/neck of the helping

radiographer (6°) was classified as “acceptable”, while trunk flexion (42°) was “conditionally acceptable” and the arms (83°) “not acceptable” (Table 48 and Figure 15, Appendix VIII).

Patient handling to remove the detector from under the patient’s back required a trunk and arms flexion from the helping radiographer to lift the patient. The head/neck remained with a slight flexion to have an overview of patient and detector removal. According to the European norm, “conditionally acceptable” classification was attributed to trunk posture (30°), and “not acceptable” to the arm (78°). The angle formed by the head/neck (9°) was “acceptable” (Table 48 and Figure 15, Appendix VIII).

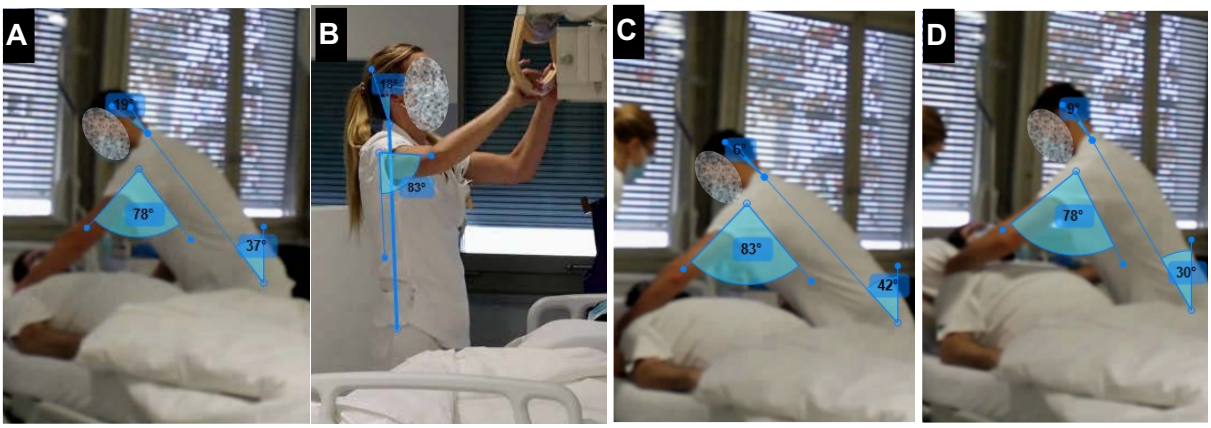


Figure 8 - “Not acceptable” postures assumed by the medium (performer) and taller (helper) radiographers during bedside chest X-ray examination scenario 3: a) the taller radiographer during the preparation to position the detector under the patient's back; b) the medium radiographer during the X-ray tube positioning; c) the taller radiographer during the preparation to remove the detector from under the patient’s back; d) the taller radiographer during the patient handling to remove the detector from under the patient’s back.

Scenario 4 - Medium radiographer (performer) & shorter radiographer (helper)

In this scenario, assumed postures with an “not acceptable” component according to the European Norm are illustrated in Figure 9.

Preparation to position the detector under the patient’s back required to lift the patient having both radiographers with the trunk and the head/neck flexed over the patient. The helping radiographer slid both arms under the patient’s back to support him. The performing radiographer placed the right arm under the patient's back to support the helping radiographer handling the patient. The trunks (Rad 2=54°; Rad 3=39°) and the arms (Rad 2=38°; Rad 3=32°) of both radiographers assumed a “conditionally acceptable” position, while the head/neck of the helping radiographer (-12°) was “not acceptable” (Table 49 and Figure 16, Appendix VIII).

Patient handling and detector positioning under the patient’s back required the exertion of force from both radiographers with the trunk straightened and the arms aligned with the trunk. The performing radiographer's trunk flexion provided an overview of the patient, while the helping

radiographer needed to tilt forward the head/neck. The performing radiographer slid the detector under the patient's back maintaining the same posture. The postural assessment of the trunk position (Rad 2=36°; Rad 3=24°) was considered as "conditionally acceptable" in both radiographers. The arms (Rad 2=0°; Rad 3=0°) and head/neck (Rad 2=0°; Rad 3=28°) angles were assessed as "acceptable" (Table 49 and Figure 16, Appendix VIII).

The control of detector position was performed by the helping radiographer, tilting the head/neck downward to verify the detector's position. The trunk and the arms were flexed to reach the detector and to adjust it. The trunk (30°) and arm (35°) assumed a "conditionally acceptable" position during flexions and the head/neck (30°) "acceptable" flexion during the control of the detector position (Table 49 and Figure 16, Appendix VIII).

X-ray tube positioning. In a first moment, the performing radiographer's trunk and arms were maintained in a vertical position without inclination, while waiting the helping radiographer to pass the tube. The head/neck was slightly extended to observe the helping radiographer doing the maneuver. The trunk (0°) and arms (0°) were in a neutral and straight position being considered as "acceptable". The head/neck extension (-18°) was rated as a "not acceptable". Then, the tube positioning was done by the performing radiographer by holding the arms up and extending the head/neck to tilt the X-ray tube and control its inclination. The angle measured in the trunk (0°) was "conditionally acceptable" but the arms (75°) and head/neck (-20°)were in "not acceptable" positions (Table 49 and Figure 16, Appendix VIII).

Preparation to remove the detector from under the patient's back required the radiographers to prepare themselves to raise the patient. Both radiographers slipped their hands under the patient's back by passing under the axilla. The helping radiographer put the other hand under the patient's scapula. The radiographers flexed both arms and trunk to support the patient's back. The performing radiographer slightly bent the head/neck downward while the helping radiographer extended it. The trunks (Rad 2=48°; Rad 3=42°) and arms (Rad 2=24°; Rad 3=34°) were assessed as "conditionally acceptable" positions. The head/neck posture of the helping radiographer (-19°) was "not acceptable" (Table 49 and Figure 16, Appendix VIII).

Patient handling to remove the detector from under the patient's back. Both radiographers slightly flexed their head/neck to have an overview of the patient and detector removal. The radiographers' trunks remained flexed but straightened compare to the previous situation, as well the arms' flexions the head/neck since they were exerting force to lift the patient. The radiographers' trunks positions (Rad 2=34°; Rad 3=22°) were "conditionally acceptable" in both radiographers. The postural assessment revealed that the posture of arms (Rad 2=0°; Rad 3=16°) and heads/necks (Rad 2=15°; Rad 3=13°) were "acceptable" (Table 49 and Figure 16, Appendix VIII).

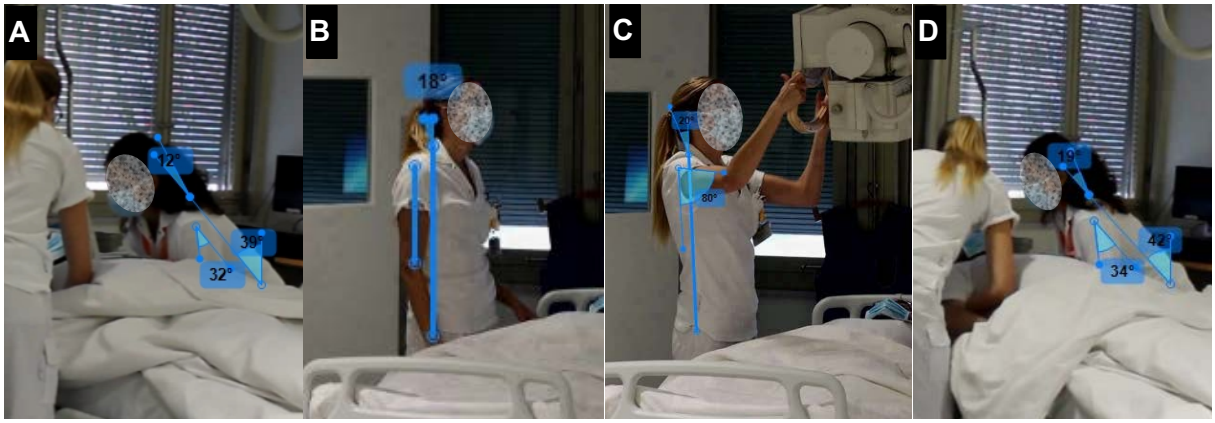


Figure 9 - "Not acceptable" postures assumed by the medium (performer) and the shorter (helper) radiographers during bedside chest X-ray examination in scenario 4: a) the shorter radiographer during the preparation to position the detector under the patient's back; b) medium radiographer while waiting for the X-ray tube; c) medium radiographer during the X-ray tube positioning; d) shorter radiographer during the patient handling to remove the detector from under the patient's back.

Scenario 5 - Shorter radiographer (performer) & taller radiographer (helper)

In this scenario, assumed postures with an "not acceptable" component according to the European Norm are illustrated in Figure 10.

During the *preparation to position the detector under the patient's back*, the radiographers bended over to place their hands to lift the patient. The performing radiographer put the right arm under the scapula passing by under the axilla, which required the upper arm's flexion. The helping radiographer also flexed the upper arms to put the hands on the patient's shoulders. Besides, the head/neck of the taller radiographer was bending downward to observe the patient. The trunk angles (Rad 3=48°; Rad 1=41°) were determined as "conditionally acceptable" in both radiographers. The upper arm flexion of performing radiographer (32°) was considered "conditionally acceptable", while the arm flexion in helping radiographer (77°) was considered as "not acceptable". The head/neck angle of the helping radiographer (21°) was classified as "acceptable" (Table 50 and Figure 17, Appendix VIII).

Patient handling and detector position under the patient's back required from the helping radiographer to apply force to pull the patient back to allow the performing radiographer to slide the detector under the patient. Their trunks were less flexed when compared to the previous situation. The visible arms were flexed to support the pulled patient. Both radiographers flexed the head/neck to observe the position of the detector. The performing radiographer slid the detector under the patient. This action did not induce a change in the posture. Radiographers' trunks (Rad 3=32°; Rad 1=24°) were in a flexion considered as "acceptable". The performing radiographer arm's angle was considered as "conditionally acceptable" (30°) while the helping radiographer (67°) was considered as "not acceptable".

The angles of the head/neck were both classified as “acceptable” (Rad 3=9°; Rad 1=21°) (Table 50 and Figure 17, Appendix VIII).

Control of detector position. In this scenario, both radiographers controlled and adapted the position of the detector under the patient. The head/neck, trunk and upper arm segments were in flexion. These segments' angles were more critical in the taller radiographer due to the difference between his height and the patient bed's height. The body segments measured in performing radiographer were all rated as “acceptable” (trunk=14°; arm=13°; head/neck=30°). The posture adopted by the helping radiographer required to assume a “conditionally acceptable” angle in the trunk (47°) and arms (49°), only the flexion of the neck (13°) was “acceptable” (Table 50 and Figure 17, Appendix VIII).

X-ray tube positioning required from the performing radiographer to raise the arms above the head, in hyperflexion, due to a need for sufficient distance between the source (tube) and the detector. The head/neck was flexed, allowing observation of patient position, the centering and diaphragms verification. The trunk was in an orthostatic posture aligned with the body's mid-sagittal plane. The radiographer’s posture was considered as “acceptable” regarding measured angles of trunk (0°) and head/neck (31°), while arms flexion (119°) was classified as “not acceptable” (Table 50 and Figure 17, Appendix VIII).

During the *preparation to remove the detector from under the patient’s back*, the performer radiographer flexed the trunk to reach the patient’s back passing under the axilla and extended the head/neck. By taking the patient by the shoulders, the helping radiographer was less downward bent than performing radiographer. The visible arms of both radiographers were flexed in order to support the patient’s back. The postural assessment of the performing radiographer revealed that angles of the trunk (50°) and right arm (38°) were “conditionally acceptable”, but “not acceptable” for head/neck (-27°). The helping radiographer’s head/neck (17°) and trunk (33°) positions were “acceptable” but the arm (74°) was in a “not acceptable” position (Table 50 and Figure 17, Appendix VIII).

Patient handling to remove the detector from under the patient's back required force from both radiographers while maintaining a flexion of the trunk. The arms and head/neck were also in flexion to support the patient’s back and keep the patient lifted to remove the detector, observing the patient at the same time. Performing radiographer’s trunk position (14°) was classified as “acceptable” while the helping radiographer’s trunk (24°) was considered as “conditionally acceptable”. The patient handling required to the helping radiographer to adopt an arm flexion (61°) considered as "not acceptable", but “acceptable” to the performing radiographer (20°). The flexion of the head/neck (Rad 3=20°; Rad 1=20°) was “acceptable” for both radiographers (Table 50 and Figure 17, Appendix VIII).

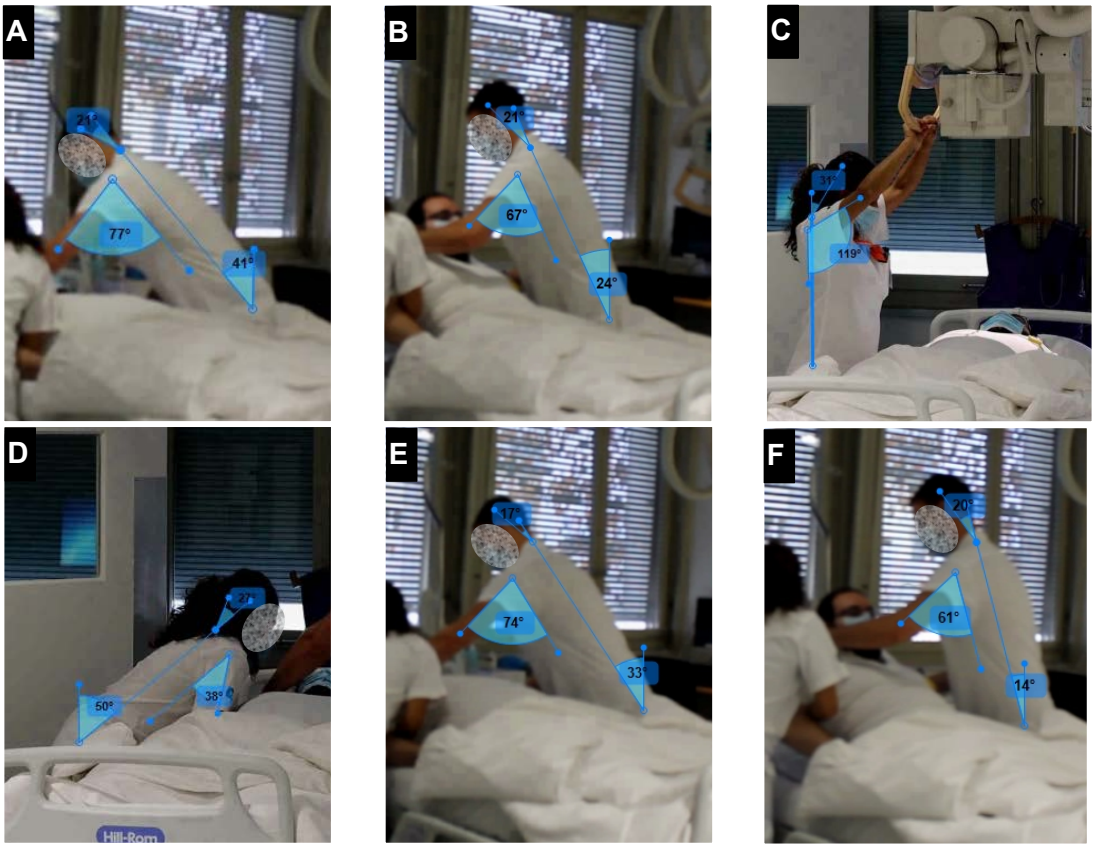


Figure 10 - "Not acceptable" postures assumed by the shorter (performer) and taller (helper) radiographers during bedside chest X-ray examination in scenario 5: a) the taller radiographer during the preparation to position the detector under the patient's back; b) the taller radiographer during the patient handling to position the detector under the patient's back; c) the shorter radiographer during the X-ray tube positioning; d & e) the shorter and taller radiographer during the preparation to remove the detector from under the patient's back; f) the taller radiographer during the patient handling to remove the detector from under the patient's back.

Scenario 6 - Shorter radiographer (performer) & medium radiographer (helper)

In this scenario, assumed postures with an "not acceptable" component according to the European Norm are illustrated in Figure 11.

Preparation to position the detector under the patient's back. In the phase, the performing radiographer preplaced the detector along the patient's arm. Both radiographers prepare to lift the patient by bending downward the trunk. The helping radiographer placed both hands over the patient's shoulders and the performing radiographer under the patient's scapula, both exerting an arm flexion. The head/neck of the performing radiographer stayed straight and aligned with the trunk, while the helping radiographer had the head/neck slightly extended. The "conditionally acceptable" classification was attributed to the trunk of both radiographers (Rad 36°; Rad 2=49°), as well as to the arm position of the performing radiographer (27°). The arm (91°) and head/neck's angles (-16°) of helping radiographer were considered as "not acceptable" (Table 51 and Figure 18, Appendix VIII).

The patient handling to position the detector under the patient's back required the exertion of force from both radiographers to lift the patient and a flexion of their trunk. The arms were and flexed. The heads/necks were slightly tilted downward to have an overview of the patient and the detector positioning. In both radiographers, the trunks postures (Rad 3= 24°; Rad 2=21°) were considered as "conditionally acceptable", while the arms of the performer (Rad 2=68°) were in a "not acceptable" position and "acceptable" in helper (Rad 3=0°). The helping radiographer's head/neck posture (13°) was also rated "acceptable" (Table 51 and Figure 18, Appendix VIII).

To Positioning the detector under the patient's back, the performing radiographer flexed the trunk to place the detector after lifting the patient. The head/neck remained in a neutral position aligned with the trunk allowing the observation of detector position by looking over the patient's shoulder. The visible arm of the radiographer was slightly flexed. The trunk (41°) and arm flexion (36°) were rated as "conditionally acceptable", while head/neck posture (0°) was considered as "acceptable" (Table 51 and Figure 18, Appendix VIII).

Control of detector position was done by the performing radiographer, requiring a flexion of the trunk and head/neck. The arms were slightly flexed to reach the detector and to readjust its position. The performing radiographer's trunk posture (48°) was classified as "conditionally acceptable" but the angles of the arm (8°) and head/neck (23°) were "acceptable" (Table 51 and Figure 18, Appendix VIII).

X-ray tube positioning required from the performing radiographer, arms' hyperflexion to reach and positioning it. The trunk was slightly extended, while the head/neck was tilted downward to observe the centering and diaphragms adjustments, promoting a "conditionally acceptable" posture of the trunk (-4°), "not acceptable" angle for arms (98°) and "acceptable" for head/neck (Table 51 and Figure 18, Appendix VIII).

During the *preparation to remove the detector from under the patient's back*, both radiographers bend the trunk over the patient. The helping radiographer lifted the patient by the shoulders and the performing radiographer helped by supporting the patient by the arm using the right hand. The performing radiographer's left hand stayed free to remove the detector. The head/neck posture of the performing radiographer was neutral and aligned with the trunk, while the helping radiographer assumed an extension of the head/neck. The trunks postures of both radiographers (Rad 3=36°; Rad 2=54°) were classified as "conditionally acceptable". The helping radiographers' posture of arms (103°) and head/neck (-24) were determined as "not acceptable". The arm flexion (21°) in performing radiographer was "conditionally acceptable", while head/neck angle was not measurable (Table 51 and Figure 18, Appendix VIII).

Patient handling to remove the detector from under the patient's back required force from radiographers to straighten their trunk and to lift the patient. The arms' flexion was also required, and the heads/necks assumed a flexion to allow the observation of the patient during detector's removal. The posture assumed by the performing radiographer was rated as "acceptable" in all body segments (≥0 and ≤20°), but the helping radiographer's posture was "conditionally acceptable" for the trunk (32°), "not acceptable" to the arm position (77°) and "acceptable" to the head/neck posture (10°) (Table 51 and Figure 18, Appendix VIII).

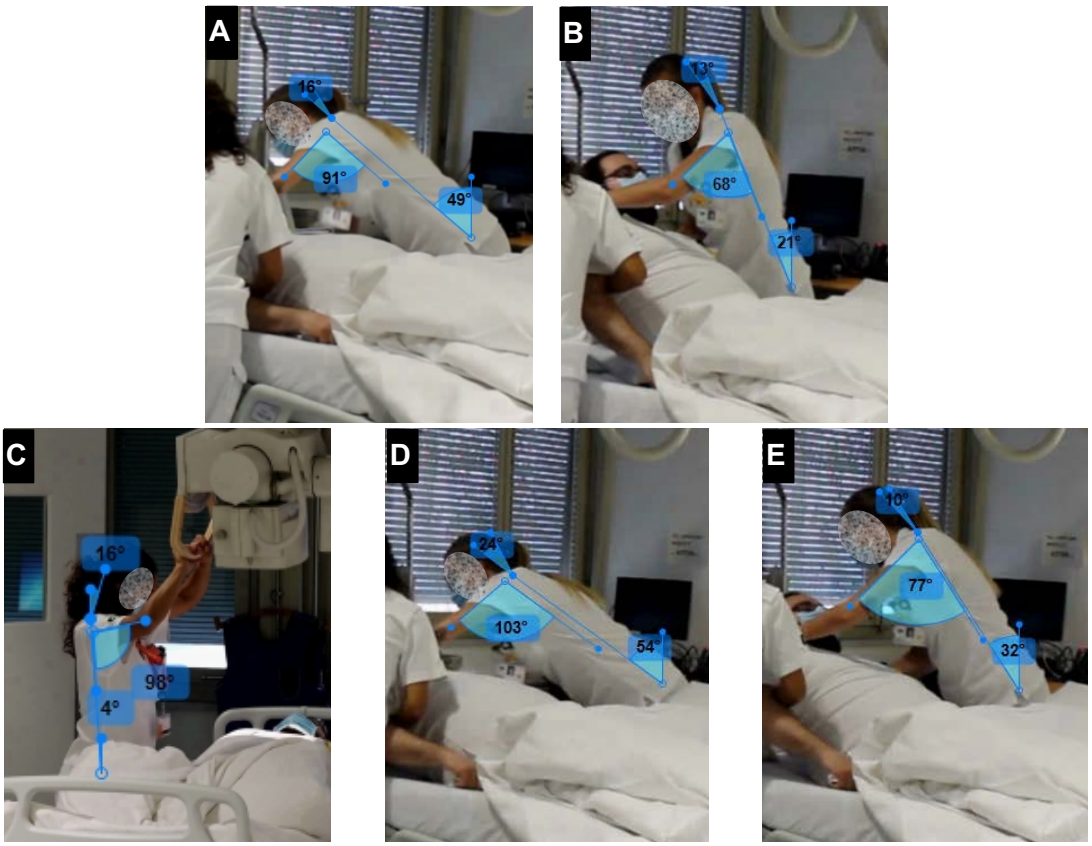


Figure 11 - "Not acceptable" postures assumed by the shorter (performer) and medium (helper) radiographers during bedside chest X-ray examination in scenario 6: a) the medium radiographer during the preparation to position the detector under the patient's back; b) medium radiographer during the patient handling to position the detector under the patient's back; c) the shorter radiographer during the X-ray tube positioning; d) the medium radiographer during the preparation to remove the detector from under the patient's back; e) the medium radiographer during the patient handling to remove the detector from under the patient's back.

5 DISCUSSION

This section presents three sections: characterization of WRMSDs symptoms in radiographers; characterization of the radiographers' postures; and limitations of the study.

5.1 CHARACTERIZATION OF WRMSDS SYMPTOMS IN RADIOGRAPHERS

The findings of this study reveal that radiographers from Western Switzerland presented a set of symptoms that may be related with WRMSDs. A high prevalence of WRMSDs symptoms in the last 12 months, the most the anatomical regions most concerned by symptoms being neck, lower back, upper back, and shoulders. Similar results were also observed in other studies carried out internationally on radiographers with a prevalence raging from 67.0% to 98.3% (Table 10), but also in nursing populations (Boocock et al., 2019; Magnago et al., 2012; Ribeiro et al., 2017). Some differences, however, emerged regarding the affected anatomical regions (Table 10) which may be explained by the specificities of each work context, such as occupational task endorsed, patient characteristics, equipment related to imaging modality, and work environment. While this study showed complains on neck and lower back, other studies showed as most frequent lower back symptoms (Bos et al., 2007; Griffin, 2018; Hanania et al., 2020; Lorusso et al., 2007; Ribeiro et al., 2017; Serranheira, Cotrim, Rodrigues, Nunes, & Sousa-Uva, 2012).

Studies on 7-days prevalence of WRMSDs symptoms were missing concerning radiographers but it can be noted that the same anatomical regions remain prevalent at 12 months and 7 days. The consistency of symptoms over time suggests that modalities and/or tasks performed by the radiographers continuously involved and stressed the same anatomical regions.

Table 10 - Comparison of WRMSDs symptoms in the last 12 months with international studies in radiographers.

Study	**Radiological field / Imaging modality**	**WRMSDs symptoms prevalence by anatomical region (12 months)**						
		Any region	*Neck*	*Upper back*	*Lower back*	*Shoulders*	*Elbows*	*Wrists/ Hands*
Lamar, 2004	Diagnostic radiographers	88.9%	52.2%	-	73.3%	36.7%		31.1%
Lorusso et al., 2007	X-ray radiographers	67.0%	19.7%	-	59.6%	21.2%		12.3%
Feng et al., 2016	Sonographers	98.3%	93.5%	72.8%	83.2%	92.2%	41.8%	79.7%
Griffin, 2018	Therapeutic radiographers	81.0%	76.0%	54.0%	78.0%	73.0%	29.0%	51.0%
Hanania et al., 2020	Therapeutic radiographers	-	17.0%	-	20.0%	15.0%	-	-
This study	**Diagnostics**	**95.1%**	**74.0%**	**46.4%**	**70.6%**	**56.6%**	**15.1%**	**25.3%**
	Nuclear medicine	**94.3%**	**68.6%**	**45.7%**	**57.1%**	**48.6%**	**22.9%**	**31.4%**
	Radiotherapy	**93.2%**	**71.2%**	**37.3%**	**59.3%**	**55.9%**	**18.6%**	**22.0%**
	Radiographers (as a group)	**94.7%**	**73.0%**	**44.9%**	**67.4%**	**55.7%**	**16.4%**	**25.4%**

Musculoskeletal disorders affects radiographers' general health but also their professional practice, having as potential consequences loss of productivity, absenteeism, early retirement or in some cases the end of career (Pallotta & Roberts, 2017). Since the WRMSDs symptoms presence and high pain severity induced a higher rate of absenteeism (European Occupational Safety and Health Administration, 2019; Magnago et al., 2012; Maumet et al., 2005), it could be expected that radiographers with a high prevalence of WRMSDs symptoms and high pain severity would have a high absenteeism (as identified here - 15.6%). Furthermore, pain intensity and frequency are also interesting indicators of WRMSDs severity since the length of absenteeism is typically proportional to the pain severity (Magnago et al., 2012). This observation should be considered in the risk management and prevention strategies of WRMSDs to reduce the frequency and length of work absences related to WRMSDs. The impact of WRMSDs is not limited to the concerned radiographers. The loss of productivity and absenteeism impact all imaging department by increasing the workload and work pace to other radiographers to keep the performance, which can create tensions and stress in the remaining team and, consequently the risk of new injuries (Pallotta & Roberts, 2017).

Almost 70% of participants self-associated musculoskeletal symptoms for all imaging modalities practiced by them, being lower back the most common symptoms. An interesting exception is nuclear medicine laboratory activity which affects mostly wrists/hands, suggesting that the manipulation of small and heavy equipment is demanding for this anatomical region. Since wrists/hands symptoms were not prevalent in this study, it may be important to take in account this observation into future prevention strategies: i) reduction of WRMSDS symptoms in general or ii) reduction of WRMSDs in a specific activity/imaging modality. Further research is needed for a better understanding since in Western Switzerland, radiographers' practice more than one imaging modality.

Associative analyses highlighted some of ergonomic, physical, organizational/psychosocial risk factors, and individual characteristics as the main factors increasing the risk of WRMSDs in spine and shoulders, which is consistent with the multifactorial nature of these health disorders (European Occupational Safety and Health Administration, 2019, 2020). In this study, the risks of spine and shoulders injuries were increased by ergonomic factors as working in awkward postures and physical force demands. These factors have previously been identified as common sources of WRMSDs in radiographers (Kumar et al., 2004b; Lorusso et al., 2007) since radiographers need to handling the patient, the equipment and respective accessories as part of their daily tasks. Inadequate physical environment and furniture were also found as sources of spine and shoulders pain which was expected since absence of adequate ergonomic conditions affects workers' safety and health (World Health Organization, 2010). An improving on physical environment conditions by reducing the noise, adjusting the

illumination, and providing adequate furniture to support a wider range of anthropometric differences are other aspects that can reduce the risks. Besides ergonomic and physical risk factors, organizational/psychosocial factors were recognized as contributing and/or aggravating WRMSDs symptoms in nursing and radiology sectors (Augner & Kaiser, 2019; Boocock et al., 2019; Bos et al., 2007; Oakman et al., 2014; Pompeii et al., 2008). Freimann et al. (2016) identified work pace, low justice and respect in the workplace, influence on work organization, role conflicts and somatic stress symptoms affecting WRMSDs occurrence in nurses, as did Augner & Kaiser (2019) for depressive symptoms in radiographers. These earlier studies are in line with the present work, regarding the time allocated to complete the tasks, and also mental health issues as anxiety/stress, and satisfaction with professional activity. The psychological load may be related to working on their own for a major part of occupational activities (although under radiologist control and patients' pressure) and facing organizational constraints of workflow. High workload may be responsible for dissatisfaction and resentment of staff negatively impacting the work environment, and patient safety (Pallotta & Roberts, 2017). Finally, the results evidenced relationships between radiographers' WRMSDs symptoms in spine, shoulders with individual characteristics, such as gender and presence of diseases. Although varying from individual to individual, their association with WRMSDs symptoms shows the need of integrating these factors in the risk assessment to have a successful prevention program (CISME, 2015; Ribeiro et al., 2017).

5.2 CHARACTERIZATION OF THE RADIOGRAPHERS' POSTURES

Multiple observations of radiographers of patient care were performed to identify main tasks and ensured accuracy of the identified "real work". The time taken to complete beside chest plain radiography during simulations was slightly shorter when compared to the time required to perform the examination with real patients, probably due to the standardized context. However, the body segments used to perform the tasks were similar to postures assessed. For these reasons, it can be state that the simulations are representative of the radiographers' clinical.

Postural strain in radiographers' occupational activity, such as reported during patient and equipment handling (Kumar et al., 2003; Pompeii et al., 2009), were also observed in this study during bedside chest plain X-ray simulations. The most demanding postures assumed by radiographers as "performers" mainly occurred during the X-ray tube manipulation requiring arm flexion, being more evident for radiographers that were shorter. For shorter radiographers, the arm flexion is important due to the need to respect a certain distance between the source of x-ray (tube) and the detector. There is a lack of literature on the impact of anthropometric

characteristics of radiographers performing X-rays, but mammography related studies showed that not adjustable radiological equipment to anthropometrics characteristics, is a physical risk factor, requiring radiographers to assume awkward postures, which increases the risk of developing WRMSDs symptoms (Cernean et al., 2017; Costa et al., 2014). It seems important to improve communication between users, equipment manufacturers and designers to fit the needs of a wider range of anthropometrics characteristics.

From “helping radiographer” viewpoint, patient handling required upper arm flexion that was “not acceptable” when holding and pushing the patient by the shoulders. This arm posture may increase the risk of injuries especially because it requires exertion of force, and it is a movement often repeated during the examination. In contrast, by supporting patients under the axilla, the constraint of the upper arm was reduced as well as the trunk flexion, remaining as an “acceptable” posture. This observation indicates a need of training to improve radiographers postures and reduce the risks associated with manual patient handling (International Organization for Standardization, 2012; Kim & Roh, 2014). Unacceptable neck extensions were observed in the medium and shortest radiographers while handling the patient, probably to have a general overview of the patient (Cernean et al., 2017; Giger et al., 2008).

The simulations also revealed differences in practice for the medium radiographer. In scenario 3, while the taller radiographer played the “helping radiographer”, the medium radiographer did not help during patient handling, in contrast, in scenario 4, the medium radiographer supported the shorter radiographer acting as “helping radiographer”. This response may be explained by the required physical force to perform the task, being higher when radiographers were shorter. Since bedside chest radiography is one of the most performed examination requiring repeated movements and awkward postures, a particular attention should be paid to biomechanical load. One strategy to reduce this physical constraint is the collaboration of both radiographers to lift the patient. Another one is changing the bedside radiography procedure, for instance raising the upper side of the bed to 45º, which will reduce the main risk factors doing the X-ray.

Anthropometric differences between radiographers also impacted the postures assumed by the radiographers; the more the performing radiographer is shorter and the helping radiographer is taller, the more “non-acceptable” postures were identified. Special attention should be paid to anthropometric differences between radiographers through ergonomic education and strategies to reduce stressful postures. It may also be beneficial to promote collaboration with radiographers with similar anthropometric characteristics as often as possible.

Most of the radiographers self-associated conventional radiography with lower back complaints, which is in line with previous studies (Lorusso et al., 2007). The trunk posture was mainly classified as “acceptable”; however, the repetitive truck flexion with exertion of force to lift the patient may increase the risk of WRMSDs symptoms. Preventive action for this specific imaging modality needs to be considered as a priority to improve physical well-being, but further research is needed to identify the specific causes.

5.3 LIMITATIONS

One of the limitations of this study was related to the online survey since it was disseminated only in French speaking part of Switzerland. The survey was running during a pandemic period which could impact the response rate despite several reminders. Furthermore, it is important to note that the population included in the study could be over or underestimated since the response rate was calculated based on an estimated number of radiographers.

The voluntary basis of the survey may have induced a non-response bias, which cannot be excluded since non-response analysis could not be performed due to lack of data. Radiographers with WRMSDs symptoms may be more motivated to participate explaining the high prevalence obtained. Since questionnaire have been completed retrospectively, recall bias cannot be excluded. Finally, the cross-sectional design does not permit a causative interpretation of WRMSDs risk factors identified.

In the second phase, the postural assessment was performed from data collected during simulations to not disturb workflow and not to film the patients, which does not allow a performance assessment in the “real” clinical context. Only one type of bed, patient and radiological equipment was considered in this project, limiting the variations present in the clinical context. The rotation of body segments was not assessed, although these movements are responsible for locomotor system injuries as WRMSDs. Working postures variability in the same radiographer across featured scenarios was not evaluated. The postural assessment was only conducted for one type of examination in conventional radiography, and other aspects were disregarded as organizational, environmental, and educational.

6 CONCLUSIONS

Work-related musculoskeletal disorders revealed to be an occupational health problem amongst Western Switzerland radiographers. The high prevalence of WRMSDs symptoms in the last 12 months (94.7%) and last 7 days (67.7%) affects predominantly neck, lower back, upper back and shoulders. In terms of severity, the absenteeism rate was relatively high (15.6%), which may be related to the high pain intensity and frequency (respectively, in 49.9% and 40.9% of the total of participants). Results highlighted the presence of ergonomic, physical, psychosocial/organizational risk factors and other relevant individual characteristics related to the self-reported WRMSDs symptoms, with some having an important effect (OR>2). Working in awkward postures revealed to be a main risk factor significantly affecting the neck within the last 12 months and 7 days (respectively, OR=2.15; 95% CI 1.33-3.49 and OR=2.01; 95% CI 1.21-3.34), lower back in the last 12 months (OR=2.86; 95% CI 1.78-4.58) and shoulders in the last 7 days (OR=2.46; 95% CI 1.31-4.61). The same tendency was observed in the upper back (OR=2.16; 95% CI 1.16-4.03) and shoulders (OR=2.43; 95% CI 1.23-4.80) in the last 12 months in radiographers unsatisfied with their work.

Observation of clinical activity allowed characterization of the real work performed during bedside chest plain radiography, and simulations allowed the identification of “not acceptable” postures for upper limbs and/or head/neck, especially during patient handling and the X-ray tube manipulation. During patient handling, the collaboration of radiographers with anthropometric differences did affect the postures classification, manual handling techniques, and radiographers’ practice. Anthropometric characteristics also directly impacted the postures of the arm during X-ray tube positioning.

Since WRMSDs symptoms affect healthcare workers’ general health, the quality of care and patient safety can suffer impacts, being important to make all stakeholders aware of this problem. These results emphasize the urgent need of improving work conditions to provide a safe environment and reduce the risk of injuries. Furthermore, considering the multifactorial nature of WRMSDs, prevention programs are needed to reduce or eliminate occupational risk factors, decreasing the prevalence of WRMSDs symptoms amongst radiographers. Further studies are required to attain a better understanding of the issues and to complete the findings for Swiss radiographers.

7 RECOMMENDATIONS AND FURTHER WORK

This work provides knowledge of Swiss Western radiographers that can be used by medical imaging departments, occupational health departments, health policies, and medical equipment designers to improve working conditions and to prevent workers' healthcare risks. Indeed, the findings gave a WRMSDs symptoms baseline in terms of prevalence and severity, and also the main risk factors, including working postures in bedside chest X-ray. Occupational health prevention programs are especially important, since radiographers' health outcomes are expected to influence patient safety (Carayon et al., 2007; Sikorski, 2009). Interventions could be initiated based on the study's findings to address WRMSDs health problems and associated economic costs.

Nevertheless, further studies are needed to acquire a more comprehensive understanding of the findings and evaluate the associations between the symptoms and specific tasks performed by radiographers, by imaging modality, similarly to what was done in other studies involving nurses (Ribeiro et al., 2017; Serranheira, Cotrim, Rodrigues, Nunes, & Sousa-Uva, 2012). Simulations revealed the assumption of "not acceptable" postures during patient handling, and other factors need to be considered for radiographers' practice WRMSDs risk assessment. The International Organization for Standardization Technical Report (ISO/TR 12296) suggests using risk assessment methods to have a more comprehensive risks understanding of manual handling during bedside chest plain X-ray, by taking into account, not only, the identified awkward postures, but also the repetitiveness, the frequency, the type and condition of the patient, the physical effort exerted, the used equipment for handling patients, the layout and rooms physical space, and also workers' WRMSDs education and training (International Organization for Standardization, 2012).

Further research should develop and implement an intervention to reduce WRMSDs incidence in radiographers. To ensure a successful intervention, participatory ergonomics includes all stakeholders, including radiographers, since workers are experts in their professional activity, and may have an important role to play in solutions development and implementation success (Burgess-Limerick, 2018; Carayon et al., 2007). An ergonomic approach could be used to improve working conditions since all risk factors dimensions need to be considered. We recommend focusing the intervention on the most prevalent symptoms, associated risk factors and most solicited body segments.

Concerning the main risk factors identified in this study and the main recommendations in the literature, recognizing early WRMSDs symptoms and exposure to risk factors, in line with the use of assistive devices, automatized conventional radiography room, and education and training programs such as "back school" and patient-handling training, is expected to contribute

to reduce physical workload and promote radiographers health and safety at work (Cernean et al., 2017; European Occupational Safety and Health Administration, 2020; Rieker-Agranier & Golay, 2008).

Improvements in environmental conditions and investment in ergonomic furniture were expected as contributors to reducing symptoms growth. In addition, to relieve radiographers from organizational/psychosocial stress, organizational interventions, as changing schedules, ensuring management support, workflow reorganization, and, for instance, doing stress management classes (Alhasan et al., 2014), could be undertaken.

Health promotion programs at the workplace will be also desirable as a strong measure for radiographers' health and safety. Prevention programs that pretend healthy lifestyles, physical exercise classes at work, a balanced diet in the cafeterias, alcohol and tobacco prohibition in healthcare environments, and, of course, a participative, systemic and integrated occupational health intervention will contribute to a better healthcare workers health (European Occupational Safety and Health Administration, 2020).

REFERENCES

Acaröz Candan, S., Sahin, U. K., & Akoğlu, S. (2019). The investigation of work-related musculoskeletal disorders among female workers in a hazelnut factory: Prevalence, working posture, work-related and psychosocial factors. *International Journal of Industrial Ergonomics*, *74*(September). https://doi.org/10.1016/j.ergon.2019.102838

Addiction Suisse (Ed.). (2013). *Alcool et santé*. https://www.addictionsuisse.ch/fileadmin/user_upload/DocUpload/alcool_sante.pdf

Alhasan, M., Abdelrahman, M., Alewaidat, H., Almhdawi, K., & Nazzal, M. (2014). Work-related stress, musculoskeletal disorder complaints, and stress symptoms among radiographers in the northern part of Jordan. *Journal of Medical Imaging and Radiation Sciences*, *45*(3), 291–298. https://doi.org/10.1016/j.jmir.2014.04.002

Arvidsson, I., Gremark Simonsen, J., Dahlqvist, C., Axmon, A., Karlson, B., Björk, J., & Nordander, C. (2016). Cross-sectional associations between occupational factors and musculoskeletal pain in women teachers, nurses and sonographers. *BMC Musculoskeletal Disorders*, *17*(1). https://doi.org/10.1186/s12891-016-0883-4

Augner, C., & Kaiser, G. (2019). Predictors of musculoskeletal symptoms in radiology technologists in Austria, Europe. *Work*, *64*(4), 853–858. https://doi.org/10.3233/WOR-193047

Aurelia-Mihaela, S., Petreanu, V., Kuhl, K., & Karla, V. den B. (2020). *Risk factors for musculoskeletal disorders development: hand-arm tasks, repetitive work*. https://oshwiki.eu/wiki/Risk_factors_for_musculoskeletal_disorders_development:_hand-arm_tasks,_repetitive_work#Work_environment

Ballinger, J. M., Comello, R. J., & Vealé, B. (2008). Stressors That Negatively Affect the Health of Radiology Professionals. *Journal of Medical Imaging and Radiation Sciences*, *39*(1), 11–15. https://doi.org/10.1016/j.jmir.2008.01.002

Boocock, M. G., Trevelyan, F., Ashby, L., Ang, A., Diep, N., Teo, S., & Lamm, F. (2019). The Influence of Psychosocial and Patient Handling Factors on the Musculoskeletal Health of Nurses. In *Musculoskeletal Disorders: Vol. III* (pp. 596–603). https://doi.org/10.1007/978-3-319-96083-8_78

Bos, E., Krol, B., van der Star, L., & Groothoff, J. (2007). Risk factors and musculoskeletal complaints in non-specialized nurses, IC nurses, operation room nurses, and X-ray technologists. *International Archives of Occupational and Environmental Health*, *80*(3), 198–206. https://doi.org/10.1007/s00420-006-0121-8

Bright Ofori-Manteaw, B., Kwadwo Antwi, W., & Arthur, L. (2015). Ergonomics and occupational health issues in diagnostic imaging: a survey of the situation at the Korle-Bu teaching hospital. *Journal of Health, Medecine and Nursing*, *19*, 93–101.

British Standard. (2018). *Safety of machinery: Human physical performance. BS EN 1005–4:2005 + A1:2008*. Swiss National Report on Quality and Safety in Healthcare.

Burgess-Limerick, R. (2018). Participatory ergonomics: Evidence and implementation lessons. *Applied Ergonomics*, *68*(August 2017), 289–293. https://doi.org/10.1016/j.apergo.2017.12.009

Carayon, P., Alvarado, C. J., & Schoofs Hundt, A. (2007). Work design and patient safety. *Theoretical Issues in Ergonomics Science*, *8*(5), 395–428. https://doi.org/10.1080/14639220701193157

Centers for Disease Control and Prevention. (n.d.). *Elements of ergonomics programs*. https://www.cdc.gov/niosh/topics/ergonomics/ergoprimer/default.html

Centers for Disease Control and Prevention. (2020). *Work-related musculoskeletal disorders (WMSDs) evaluation measures*. https://www.cdc.gov/workplacehealthpromotion/health-strategies/musculoskeletal-disorders/evaluation-measures/index.html

Cernean, N., Serranheira, F., Gonçalves, P., & Sá dos Reis, C. (2017). Ergonomic strategies to improve radiographers' posture during mammography activities. *Insights into Imaging*, *8*(4), 429–438. https://doi.org/10.1007/s13244-017-0560-7

CHUV - service radiodiagnostic et radiologie interventionnelle. (2020). *Conceptualisation prise en charge d'un patient au DIAG*.

Cleverley, J., Piper, J., & Jones, M. M. (2020). The role of chest radiography in confirming covid-19 pneumonia. *The BMJ*, *370*. https://doi.org/10.1136/bmj.m2426

Conne-Perréard, E., Glardon, M., Parrat, J., & Usel, M. (2001). *Effets de conditions de travail défavorables sur la santé des travailleurs et leurs conséquences économiques*. https://www.lomag-man.org/sante travail/rapport_ch/rapport_definitif-Effetscondtravdefav-sursantetravailleurs.pdf

Costa, S., Oliveira, E., Reis, C., Viegas, S., & Serranheira, F. (2014). Mammography equipment design: impact on radiographers' practice. *Insights into Imaging*, *5*(6), 723–730. https://doi.org/10.1007/s13244-014-0360-2

Council Directive 89/391/CEE of 12th June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work. https://osha.europa.eu/fr/legislation/directives/the-osh-framework-directive/1

Daniel, S. V., Umar, M. S., Ahmad, N. M., & Joseph, Z. D. (2018). Work-related musculoskeletal disorders : rrevalence among clinical radiographers in teaching hospitals in North-Western Nigeria. *Journal of Radiography & Radiation Sciences*, *32*(1), 57–63.

David, G. C. (2005). Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occupational Medicine*, *55*(3), 190–199. https://doi.org/10.1093/occmed/kqi082

Delalande-Danet, V., Desarmenien, A., Incorvaïa, A.-M., Letheux, C., Leviel, C., & Viossat, M. (2015). *Les troubles musculo-squelettiques*. https://www.presanse.fr/wp-content/uploads/2019/02/GUIDE-TMS-23-06-2015-Version-de-consultation.pdf

Dépatement de la formation de la jeunesse et de la culture, & Département social de la santé et de l'action sociale. (2018). *Dossier technique pour les boissons dites énergisantes (BDE) ou riches en caféine* (Canton de Vaud (Ed.)). www.vd.ch/unite-psps

Descatha, A., Roquelaure, Y., Aublet-Cuvelier, A., Ha, C., Touranchet, A., & Leclerc, A. (2010). Validité du questionnaire de type "Nordique" dans la surveillance des pathologies d'hypersollicitation du membre supérieur. *Documents Pour Le Médecin Du Travail*. https://www.hal.inserm.fr/inserm-00232629

Enevoldsen, S., & Kusk, M. W. (2020). Image quality of bedside chest radiographs in intensive care beds with integrated detector tray: A phantom study. *Radiography*, *26*(4). https://doi.org/10.1016/j.radi.2020.10.012

Eslick, G. D., & Raj, V. V. (2002). Occupational stress amongst radiographers: Does working in private or public practice make a difference? *Radiography*, *8*(1), 47–53. https://doi.org/10.1053/radi.2001.0356

European Occupational Safety and Health Administration. (2007). *Facts 71 - Introduction aux troubles musculo-squelettiques d'origine professionnelle*. https://healthy-workplaces.eu/fr/tools-and-publications/publications/factsheet-71-introduction-work-related-musculoskeletal-disorders

European Occupational Safety and Health Administration. (2019). *Work-related musculoskeletal disorders: prevalence, costs and demographics in the European Union*. https://healthy-workplaces.eu/en/tools-and-publications/publications/work-related-musculoskeletal-disorders-prevalence-costs-and

European Occupational Safety and Health Administration. (2020). Discussion paper musculoskeletal disorders in the healthcare. *European Agency for Safety and Health at Work*, 1–23. https://osha.europa.eu/en/publications/musculoskeletal-disorders-healthcare-sector/view

Evans, K., Roll, S., & Baker, J. (2009). Work-Related musculoskeletal disorders (WRMSD) among registered diagnostic medical sonographers and vascular technologists. *Journal of Diagnostic Medical Sonography*, *25*(6), 287–299. https://doi.org/10.1177/8756479309351748

Evans, K., Sommerich, C. M., Klatt, M. D., Griffin, H., & Pan, X. (2019). Self-reported symptoms of work-related musculoskeletal disorders among radiation therapists [Abstract]. *Radiation Therapist*, *28*(2), 131–142. http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=139544953&site=ehost-live

Exploration of Self-Reported Work-Related Musculoskeletal Injuries among Radiographers & Radiation Therapists. (n.d.). https://cpb-us-w2.wpmucdn.com/u.osu.edu/dist/a/41203/files/2018/07/WRMSD-Radiographers-Radiation-Therapists-Literature-review-2017-rj1qmf.pdf

Fechner, C., Strobel, K., Treumann, T., Sonderegger, B., Azzola, A., Fornaro, J., Schrading, S., & Roos, J. E. (2020). COVID-19 and the role of imaging: Early experiences in Central Switzerland. *Swiss Medical Weekly*, *150*(25–26), 1–10. https://doi.org/10.4414/smw.2020.20304

Feng, Q., Liu, S., Yang, L., Xie, M., & Zhang, Q. (2016). The prevalence of and risk factors associated with musculoskeletal disorders among sonographers in central China: A cross-sectional study. *PLoS ONE*, *11*(10), 1–18. https://doi.org/10.1371/journal.pone.0163903

Fisher, T. F. (2015). Radiologic and sonography professionals' ergonomics: An occupational therapy intervention for preventing work injuries. *Journal of Diagnostic Medical Sonography*, *31*(3), 137–147. https://doi.org/10.1177/8756479315580020

Forcier, L., Lapointe, C., Beaugrand, S., Lortie, M., Kuorinka, I., & Buckle, P. (2001). *Questionnaire sur la santé musculo-squelettique des travailleurs issu du questionnaire nordique*. Institut de recherche Robert-Sauvé en santé et en sécurité du travail. http://www.irsst.qc.ca/media/documents/pubirsst/rg1-270.pdf?i=0&redirected=1

Freimann, T., Pääsuke, M., & Merisalu, E. (2016). Work-related psychosocial factors and mental health problems associated with musculoskeletal pain in nurses: A cross-sectional study. *Pain Research and Management*, *2016*. https://doi.org/10.1155/2016/9361016

Giger, M. L., Chan, H. P., & Boone, J. (2008). Anniversary paper: History and status of CAD and quantitative image analysis: The role of Medical Physics and AAPM. *Medical Physics*, *35*(12), 5799–5820. https://doi.org/10.1118/1.3013555

Goyette, V. (2016). *Les troubles musculosquelettiques liés au travail chez les technologues en échographie générale et cardiaque*. http://asstsas.qc.ca/sites/default/files/publications/documents/DOSS_THEM/PDSB/Radiologie/TMS liés au travail (V. Goyette).pdf

Griffin, H. (2018). *Work-related musculoskeletal disorders in radiation therapists: an exploration of self-reported symptoms* [Ohio State University]. https://etd.ohiolink.edu/

Hanania, A. N., Cook, A., Threadgill, M. P., Conway, S. H., & Ludwig, M. (2020). Prevalence of musculoskeletal work-related injuries among radiation therapists [Abstract]. *Radiologic Technology*, *91*(5). https://doi.org/10.1016/S0360-3016(19)30510-3

Hellig, T., Mertens, A., & Brandl, C. (2018). The interaction effect of working postures on muscle activity and subjective discomfort during static working postures and its correlation with OWAS. *International Journal of Industrial Ergonomics*, *68*, 25–33. https://doi.org/10.1016/j.ergon.2018.06.006

Hulls, P. M., Money, A., Agius, R. M., & de Vocht, F. (2018). Work-related ill-health in radiographers. *Occupational Medicine*, *68*(6), 354–359. https://doi.org/10.1093/occmed/kqy076

International Organization for Standardization. (2012). *ISO/TR 12296:2012. Ergonomics - manual handing of people in the healthcare sector*.

Iowa State University. (n.d.). *Risk factors*. https://www.ehs.iastate.edu/services/occupational/ergonomics/risk-factors

Kapitaniak, B., Péninou, G., & Samuelson, B. (2001). *Assistance ergonomique pour la conception de mammographe - GE Medical Systems*. https://streaming-canal-u.fmsh.fr/vod/media/canalu/documents/universite_paul_verlaine_metz_sam/histoire.s.de.l.ergonomie.3.7.la.pratique.le.d.veloppement.d.un.m.tier_11649/33.kapitaniak.mammographe.pdf

Karsh, B.-T. (2006). Theories of work-related musculoskeletal disorders: Implications for ergonomic interventions. *Theoretical Issues in Ergonomics Science*, *7*(1), 71–88. https://doi.org/10.1080/14639220512331335160

Kim, T., & Roh, H. (2014). Analysis of risk factors for work-related musculoskeletal disorders in radiological technologists. *Journal of Physical Therapy Science*, *26*(9), 1423–1428. https://doi.org/10.1589/jpts.26.1423

Krebs, E. E., Carey, T. S., & Weinberger, M. (2007). Accuracy of the pain numeric rating scale as a screening test in primary care. *Journal of General Internal Medicine*, *22*(10), 1453–1458. https://doi.org/10.1007/s11606-007-0321-2

Kumar, S., Moro, L., & Narayan, Y. (2003). A biomechanical analysis of loads on x-ray technologists: A field study. *Ergonomics*, *46*(5), 502–517. https://doi.org/10.1080/0014013031000061659

Kumar, S., Moro, L., & Narayan, Y. (2004a). Morbidity among X-ray technologists. *International Journal of Industrial Ergonomics*, *33*(1), 29–40. https://doi.org/10.1016/j.ergon.2003.06.002

Kumar, S., Moro, L., & Narayan, Y. (2004b). Perceived physical stress at work and musculoskeletal discomfort in X-ray technologists. *Ergonomics*, *47*(2), 189–201. https://doi.org/10.1080/00140130310001617958

Kuorinka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sørensen, F., Andersson, G., & Jørgensen, K. (1987). Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics*, *18*(3), 233–237. https://doi.org/10.1016/0003-6870(87)90010-X

Lamar, S. L. (2004). *Investigation of factors associated with prevalence and severity of musculoskeletal symptoms among the workers in clinical specialties of radiologic technology: an ergonomic and epidemiological approach* [North Carolina State University]. https://repository.lib.ncsu.edu/handle/1840.16/143

Läubli, T., & Müller, C. (2009). *Conditions de travail et maladies de l'appareil locomoteur - Estimation du nombre de cas et des coûts macroéconomiques pour la Suisse*. https://www.seco.admin.ch/seco/fr/home/Publikationen_Dienstleistungen/Publikationen_und_Formulare/Arbeit/Arbeitsbedingungen/Studien_und_Berichte/arbeitsbedingungen-und-erkrankungen-des-bewegungsapparates---ges.html

Lehmann, P., Meystre, N. R., & Mamboury, N. (2012). *Analyse du marché du travail des Techniciens en Radiologie Médicale en Suisse en 2011 : sur mandat de l'Association Suisse des Techniciens en Radiologie Médicale ASTRM*. https://www.astrm.ch/files/Dokumente/Verband/Projekte/rapport_econcept.pdf

Loi fédérale du 13 mars 1964 sur le travail dans l'industrie, l'artisanat et le commerce (Loi sur le travail) (= LTr; RS 822.11; état le 1er janvier 2021).

López-Aragón, L., López-Liria, R., Callejón-Ferre, Á.-J., & Gómez-Galán, M. (2017). Applications of the standardized nordic questionnaire: A Review. *Sustainability*, *9*(1514), 1–42. https://doi.org/10.3390/su9091514

Lorusso, A., Bruno, S., & L'abbate, N. (2007). Musculoskeletal complaints among Italian X-ray technologists. *Industrial Health*, *45*(5), 705–708. https://doi.org/10.2486/indhealth.45.705

Luttmann, A., Jäger, M., Griefahn, B., Caffier, G., & Liebers, F. (2004). *La prévention des troubles musculo-squelettiques sur le lieu de travail*. https://apps.who.int/iris/bitstream/handle/10665/42802/9242590532.pdf?sequence=1&isAllowed=y

Macdonald, W. (2012). Conceptual framework for development of a toolkit for prevention of work-related musculoskeletal disorders. *Work*, *41*(Suppl 1), 3933–3936. https://doi.org/10.3233/WOR-2012-0689-3933

Macdonald, W., & Oakman, J. (2015). Requirements for more effective prevention of work-related musculoskeletal disorders. *BMC Musculoskeletal Disorders*, *16*(1), 293. https://doi.org/10.1186/s12891-015-0750-8

Magnago, T. S., Lima, A. C. S., Prochnow, A., Ceron, M. D. da S., Tavares, J. P., & Urbanetto, J. de S. (2012). Intensidade da dor musculoesquelética e a (in)capacidade para o trabalho na enfermagem. *Revista Latino-Americana de Enfermagem*, *20*(6), 1125–1133. https://doi.org/10.1590/S0104-11692012000600015

Maulini, O. (2010). Travail, travail prescrit, travail réel. In *FORDIF-Formation en direction d'institutions de formation*. FORDIF.

Maumet, S., De Gaudemaris, R., Caroly, S., & Balducci, F. (2005). Facteurs associés à la prévalence des troubles musculo-squelettiques en milieu hospitalier. *Archives Des Maladies Professionnelles et de l'Environnement*, *66*(3), 236–243. https://doi.org/10.1016/S1775-8785(05)79088-3

Mesquita, C. C., Ribeiro, J. C., & Moreira, P. (2010). Portuguese version of the standardized Nordic musculoskeletal questionnaire: Cross cultural and reliability. *Journal of Public Health*, *18*, 461–466. https://doi.org/10.1007/s10389-010-0331-0

Nawrocka, A., Mynarski, W., Powerska-Didkowska, A., Grabara, M., & Garbaciak, W. (2014). Musculoskeletal pain among Polish music school students. *Medical Problems of Performing Artists*, *29*(2), 64–69. https://doi.org/10.21091/mppa.2014.2015

Nunes, I., & McCauley, P. (2012). Work-related musculoskeletal disorders assessment and prevention. In *Ergonomics - A Systems Approach*. https://doi.org/10.5772/37229

Oakman, J., Macdonald, W., & Wells, Y. (2014). Developing a comprehensive approach to risk management of musculoskeletal disorders in non-nursing health care sector employees. *Applied Ergonomics*, *45*(6), 1634–1640. https://doi.org/10.1016/j.apergo.2014.05.016

Ordinance on human research with the exception of clinical trials of 20th September 2013 (= HRO; SR 810.301; état le 26 mai 2021).

Ordonnance 1 du 10 mai 2000 relative à la loi sur le travail (= OLT 1; RS 8222.111; état le 1er novembre 2020).

Ordonnance 3 du 18 août 1993 relative à la loi sur le travail (= OLT 3; RS 8222.113; état le 1er octobre 2015).

Ordonnance du 19 décembre 1983 sur la prévention des accidents et des maladies professionnelles (Ordonnance sur la prévention des accidents) (= OPA; RS 832.30; état le 1er mai 2018).

Organisation mondiale de la santé. (n.d.). *Activité physique pour les adultes*. World Health Organization. https://www.who.int/dietphysicalactivity/factsheet_adults/fr/

Pallotta, O. J., & Roberts, A. (2017). Musculoskeletal pain and injury in sonographers, causes and solutions. *Sonography*, *4*(1), 5–12. https://doi.org/10.1002/sono.12093

Pompeii, L. A., Lipscomb, H. J., & Dement, J. M. (2008). Surveillance of musculoskeletal injuries and disorders in a diverse cohort of workers at a tertiary care medical center. *American Journal of Industrial Medicine*, *51*(5), 344–356. https://doi.org/10.1002/ajim.20572

Pompeii, L. A., Lipscomb, H. J., Schoenfisch, A. L., & Dement, J. M. (2009). Musculoskeletal injuries resulting from patient handling tasks among hospital workers. *American Journal of Industrial Medicine*, *52*(7), 571–578. https://doi.org/10.1002/ajim.20704

Ransom, E. (2002). *The causes of musculoskeletal injury amongst sonographers in the UK*. Society of Radiographers. https://www.soundergonomics.com/pdf/SCOR-MSI Book.pdf

Ribeiro, T., Serranheira, F., & Loureiro, H. (2017). Work related musculoskeletal disorders in primary health care nurses. *Applied Nursing Research*, *33*, 72–77. https://doi.org/10.1016/j.apnr.2016.09.003

Rieker-Agranier, A., & Golay, A. (2008). Nouvelle approche éducative de proximité visant le retour au travail. *Revue Medicale Suisse*, *4*(151), 854–857. https://www.revmed.ch/RMS/2008/RMS-151/Nouvelle-approche-educative-de-proximite-visant-le-retour-au-travail

Rothweiler, J. (2019). *Les vertèbres, des os fragiles*. SUVA. https://www.suva.ch/fr-ch/news/2019/prevenir-les-maux-de-dos

Rubinowitz, A. N., Siegel, M. D., & Tocino, I. (2007). Thoracic Imaging in the ICU. *Critical Care Clinics*, *23*(3), 539–573. https://doi.org/10.1016/j.ccc.2007.06.001

Schmitter, D. (2010). *L'ergonomie. Un facteur de succès pour toutes les entreprises*. Suva Protection de la santé. https://re.srb-group.com/web1/images/pdf/infomaterialien/suva-f/44061-f.pdf

Serranheira, F., Cotrim, T., Rodrigues, V., Nunes, C., & de Sousa Uva, A. (2012). Nurses' working tasks and MSDs back symptoms: Results from a national survey. *Work*, *41*, 2449–2451. https://doi.org/10.3233/WOR-2012-0479-2449

Serranheira, F., Cotrim, T., Rodrigues, V., Nunes, C., & Sousa-Uva, A. (2012). Lesões musculoesqueléticas ligadas ao trabalho em enfermeiros portugueses: «ossos do ofício» ou doenças relacionadas com o trabalho? *Revista Portuguesa de Saude Publica*, *30*(2), 193–203. https://doi.org/10.1016/j.rpsp.2012.10.001

Siegal, D. S., Levine, D., Siewert, B., Lagrotteria, D., Affeln, D., Dennerlein, J., & Boiselle, P. M. (2010). Repetitive stress symptoms among Radiology technologists: prevalence and major causative actors. *Journal of the American College of Radiology*, *7*(12), 956–960. https://doi.org/10.1016/j.jacr.2010.05.024

Siewert, B., Brook, O. R., Mullins, M. M., Eisenberg, R. L., & Kruskal, J. B. (2013). Practice Policy and Quality Initiatives: Strategies for Optimizing Staff Safety in a Radiology Department. *RadioGraphics*, *33*(1), 245–261. https://doi.org/10.1148/rg.331125174

Sikorski, J. (2009). *Connecting worker safety to patient safety: a new imperative for health-care leaders*. https://iveybusinessjournal.com/publication/connecting-worker-safety-to-patient-safety-a-new-imperative-for-health-care-leaders/

Sousa, P., Sousa Uva, A., Serranheira, F., Ovretveit, J., Klazinga, N., Sunol, R., & Terris, D. D. (2009). The patient safety journey in Portugal: challenges and opportunities from a public health perspective. *Revista Portuguesa de Saúde Pública*, *Número esp*, 91–105.

Sousa Uva, A., & Serranheira, F. (2014). Saúde do trabalhador: ergonomia e segurança do paciente. In P. Sousa & W. Mende (Eds.), *Segurança do Paciente: criando organizações de saúde seguras* (Rio de Jan). Fiocruz. https://doi.org/10.7476/9788575415948.0008

Springer, T. (2007). *Ergonomics for healthcare environment*. 1–36. https://www.knoll.com/media/760/617/healthcare_ergonomics.pdf

Sullivan, G. M., & Artino, A. R. (2013). Analyzing and interpreting data from likert-type scales. *Journal of Graduate Medical Education*, *5*(4), 541–542. https://doi.org/10.4300/jgme-5-4-18

Swiss conference of cantonal health directors, & Swiss national health work organization. (2016). *Besoins en effectifs dans les professions de la santé - Rapport national 2016*. https://www.gdk-cds.ch/fileadmin/docs/public/gdk/themen/gesundheitsberufe/nichtun._gesundheitsberufe/versorgungsbericht/versorgungsbericht_2016-fr-v1.8-web.pdf

Tinetti, C. J., & Thoirs, K. (2019). Prevalence, risks, underlying mechanisms, preventative guidelines, and interventions of sonographer work-related injuries: A literature review.

Sonography, *February*, 1–14. https://doi.org/10.1002/sono.12187

Verrier, W., & Harvey, J. (2010). An investigation into work related stressors on diagnostic radiographers in a local district hospital. *Radiography*, *16*(2), 115–124. https://doi.org/10.1016/j.radi.2009.09.005

Weiner, C., Kalichman, L., Ribak, J., & Alperovitch-Najenson, D. (2017). Repositioning a passive patient in bed: Choosing an ergonomically advantageous assistive device. *Applied Ergonomics*, *60*, 22–29. https://doi.org/10.1016/j.apergo.2016.10.007

World Health Organization. (2010). *Healthy workplaces : a model for action for employers, workers, policy-makers and practitioners*. https://apps.who.int/iris/bitstream/handle/10665/44307/9789241599313_eng.pdf?sequence=1&isAllowed=y

ANNEXES

ANNEX I - AGREEMENT ETHICS COMMISSIONS

Agreement of Vaud Cantonal Ethics Commission in Human Research

COMMISSION CANTONALE
D'ÉTHIQUE DE LA RECHERCHE
SUR L'ÊTRE HUMAIN
CER-VD
Av. de Chailly 23
1012 Lausanne

Docteur Cláudia Sá Dos Reis
Haute École de Santé de Vaud
(HESAV)
Av. de Beaumont 21
1011 Lausanne

Lausanne, le 05/08/2020
Réf. BB/cc

Décision de la Commission cantonale (VD) d'éthique de la recherche sur l'être humain (CER-VD)

Project-ID	2020-01174
Titre du projet	WRMDs among radiographers of Western Switzerland: prevalence, risk factors and posture assessment.
Travail de master/de thèse de	Fernandes Kelly & Ferreira Ana
Direction du projet	Dr Cláudia Sá dos Reis, Professeure HES,
Promoteur	HESAV - Dr Cláudia Sá dos Reis, Professeure HES,
Centres	• Dr Cláudia Sá dos Reis, Professeure HES,, Haute École de Santé de Vaud (HESAV),, Lausanne

Décision

☒ Autorisation accordée
☐ Autorisation avec charges
☐ En l'état, l'autorisation ne peut pas être accordée
☐ Autorisation non accordée
☐ Non entrée en matière

Remarque les données ne doivent pas être conservées sur le PC de la personne effectuant son travail de master, mais uniquement sur un ordinateur institutionnel, afin d'éviter le risque de perte des données et d'accès non autorisé aux données. Nous vous prions de bien vouloir accuser réception de cette demande (courriel à transmettre sur BASEC).

Classification

☒ Projet de recherche au sens de l'ORH — Catégorie : A
☒ recherche sur des personnes
☐ réutilisation du matériel biologique ou des données personnelles liées à la santé
☐ sur des personnes décédées
☐ sur des embryons et des fœtus
☐ avec rayonnements ionisants

Secrétariat administratif | Tél. +41 21 316 18 30 | Secretariat.CER@vd.ch | www.cer-vd.ch Page 1 sur 4

Procédure de décision

☐ Procédure ordinaire ☐ Procédure simplifiée ☒ Procédure présidentielle

La Commission certifie se conformer aux principes ICH GCP.

Taxes et émoluments

Déjà facturé.

Voies de recours

La présente décision peut faire l'objet d'un recours au Tribunal cantonal, Cour de droit administratif et public. L'acte de recours doit être déposé auprès du Tribunal cantonal dans les **30 jours** suivant la communication de la décision attaquée ; il doit être signé et indiquer les conclusions et motifs du recours. La décision attaquée est jointe au recours. Le cas échéant, ce dernier est accompagné de la procuration du mandataire.

Copie pour information à :

☐ OFSP

☒ Autre(s) Kelly Fernandes, kelly.fernandes@master.hes-so.ch
Ana Ferreira, ana.costaferreira@master.hes-so.ch

Signature

Prof.Bernard Burnand
Vice-président ad interim

Annexes: -Obligations du requérant
-Signification des décisions possibles
-Liste des documents soumis les 07.05.2020, 05.06.2020, 27.07.2020, 30.07.2020

Bonjour madame,

La Commission d'évaluation des demandes d'enquête au CHUV (CEDE) a bien reçu votre demande et l'a enregistré avec le n° 2020-10.

Après lecture de vos documents qui sont clairs et complets et du fait que votre observation « en chambre » sera concentrée sur le TRM réalisant la prestation de radiologie et non sur le patient, la question d'informer l'ensemble des Chefs de service pouvant être potentiellement concernés par votre présence auprès du TRM dans leur service se pose. La CEDE pense que cela n'est pas utile.

Par contre, il est important que le Département de radiologie par son Chef de département, Prof. R. Meuli, et par son TRM coordinateur, L. Thomas, soit informés et vous apportent leur validation et soutien en cas de problématique avec les services, ce qui nous semble toutefois très improbable. Je mets donc Prof. Meuli et L. Thomas en copie pour avoir leur validation, si cela n'a pas déjà été fait.

Dans l'attente de cette validation, je reste à disposition concernant cet objet et vous transmets nos meilleures salutations.

Pour la CEDE :

CHUV

centre hospitalier universitaire vaudois

Patrick GENOUD

Directeur adjoint des soins

Bugnon 21 /06-210

CH-1011 Lausanne

http://www.chuv.ch/dso

ANNEX II - GRAPHICAL REPRESENTATIONS OF WORKING POSTURES

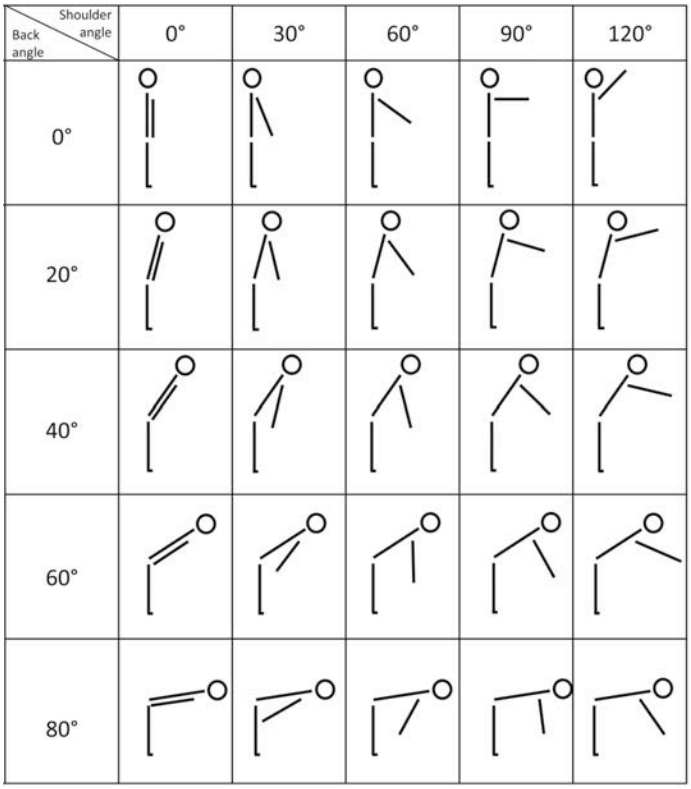


Figure 12 - Graphical representations of working postures taken from OWAS AC method (Hellig et al., 2018)[11].

[11] These graphical representations of working postures were only used during observation of clinical practice to assess the neck and upper arms' angles assumed by radiographers and not to assess ergonomics risks.

APPENDIX

APPENDIX I - SURVEY APPLIED

1. Dans quel domaine de la radiologie exercez-vous ? (Si vous travaillez actuellement dans plusieurs domaines de la radiologie, veuillez indiquer celui où vous exercez le plus grand pourcentage.)
   - ☐ Radiodiagnostic et Radiologie interventionnelle
   - ☐ Médecine Nucléaire
   - ☐ Radiothérapie

A - FACTEURS SOCIODÉMOGRAPHIQUES ET INDIVIDUELS

1. Sexe :	
☐ Féminin	☐ Masculin
2. Année de naissance : _____	
3. Poids (kg) : _____ (Seul l'Indice de Masse Corporelle (IMC) sera analysé)	
4. Taille (cm) : _____ (Seul l'Indice de Masse Corporelle (IMC) sera analysé)	
5. Fumez-vous, même occasionnellement ? (Ex: cigarette, e-cigarette, pipe)	
☐ Oui	☐ Non
6. De façon générale, consommez-vous plus d'un verre d'alcool par jour ? (FEMME)	
☐ Oui	☐ Non
7. De façon générale, consommez-vous plus de deux verres d'alcool par jour ? (HOMME)	
☐ Oui	☐ Non
8. De façon générale, consommez-vous plus de deux boissons caféinées/énergétiques par jour ?	
☐ Oui	☐ Non
9. De façon générale, exercez-vous une activité sportive régulière ? (Activité sportive: au moins 150 min/semaine d'activité physique modérée ou 75 min/semaine d'activité physique intense)	
☐ Oui	☐ Non

Les questions qui suivent sont des questions d'ordre général sur votre santé.

10. Comment décririez-vous votre état de santé général ?

□ Très bon	□ Mauvais
□ Bon	□ Très mauvais
□ Moyen	□ Ne sais pas

11. Au cours des 7 derniers jours, avez-vous pris des antidouleurs/anti-inflammatoires ? (Ex : paracétamol, ibuprofène, opiacés, opioïdes)

□ Oui	□ Non

12. Au cours des 12 derniers mois, avez-vous consulté un médecin plus de 4 fois ?

□ Oui	□ Non

13. Suivez-vous actuellement un traitement de réhabilitation ? (Ex : physiothérapie, ergothérapie)

□ Oui	□ Non

14. Souffrez-vous actuellement de maladies ou de troubles de la santé (chroniques ou aigus) ?

□ Oui	□ Non

15. Parmi les propositions ci-dessous, lesquelles sont touchées par vos maladies ou vos troubles de la santé ? (Plusieurs réponses possibles)

- □ Le système nerveux (Ex : symptômes de paralysie, épilepsie, migraines, vertiges, tumeurs).
- □ Les yeux et oreilles (Ex : troubles de la vue ou de l'ouïe, affection rétinienne, surdité, inflammations ou autres).
- □ Le système respiratoire (Ex : asthme, bronchite chronique, emphysème, pneumonie).
- □ Le système cardio-vasculaire (Ex. troubles cardiaques, tension artérielle, embolies, varices, thrombose).
- □ Le métabolisme ou du sang (Ex. diabète, goutte, anémie, leucémie, affection de la rate).
- □ Le système digestif (Ex : œsophage, estomac, vésicule biliaire, foie, pancréas, intestins, hémorroïdes).
- □ Le système urinaire ou génital (Ex. calculs, malformations, tumeurs).
- □ Le système musculo-squelettique de façon aiguë (Ex : trauma, accident)
- □ Le système musculo-squelettique de façon chronique (Ex : goutte, rhumatismes, arthrose).
- □ Le système immunitaire, maladies infectieuses ou vénériennes (Ex : tuberculose, maladie sexuellement transmissible, hépatite, maladie tropicale, parasites ou autres).
- □ Le système endocriniennes (Ex. thyroïde, surrénales, hypophyse).
- □ La peau (Ex : allergies, eczéma, psoriasis, cancers).
- □ Autres maladies, blessures ou troubles de la santé non cités.

16. Vos maladies ou vos troubles de la santé affectent-ils votre système musculo-squelettique (courbatures, douleurs ou gênes) ?

□ Oui	□ Non

17. Les courbatures, douleurs ou gênes sont-elles causées ou aggravées par votre activité professionnelle actuelle ?

□ Oui	□ Non

B - FACTEURS LIÉS AU TRAVAIL

1. Combien d'années d'expérience avez-vous en tant que TRM ? (Si vous avez arrêté votre activité professionnelle de TRM pendant une année ou plus, veuillez le soustraire au total d'années d'expérience)
   - ☐ Menu déroulant

2. Quelle(s) fonction(s) exercez-vous actuellement au sein de votre institution ? (Plusieurs réponses possibles)
   - ☐ TRM
   - ☐ Dosimétriste
   - ☐ Praticien formateur
   - ☐ TRM enseignant
   - ☐ TRM expert (Ex: expert en radioprotection, expert qualité)
   - ☐ TRM avec activité de recherche
   - ☐ Chef TRM
   - ☐ Chef TRM adjoint
   - ☐ Chef d'équipe
   - ☐ Autre

3. Depuis combien d'années travaillez-vous dans l'institution actuelle ?
   - ☐ Menu déroulant

4. Dans quel type d'institution travaillez-vous actuellement ?

(Si vous travaillez dans plusieurs types d'institutions, veuillez indiquer celle où vous travaillez le plus souvent)

   - ☐ Public et universitaire
   - ☐ Public et non universitaire
   - ☐ Privé
   - ☐ Autre:

5. Quel est votre taux d'activité professionnelle actuel ?
   - ☐ 100%
   - ☐ 90%
   - ☐ 80%
   - ☐ 70%
   - ☐ 60%
   - ☐ 50%
   - ☐ 40%
   - ☐ 30%
   - ☐ 20%
   - ☐ 10%

6. De façon générale, à quelle fréquence réalisez-vous les horaires de travail mentionnés ci-dessous ?

	Jamais	Parfois	Souvent	Tout le temps
Horaires de jour				
Horaires de nuit				
Horaires d'astreinte (sur appel)				

7. De façon générale, à quelle fréquence prenez-vous en charge les types de patients mentionnés ci-dessous ?

	Jamais	Parfois	Souvent	Tout le temps
Patients ambulatoires				
Patients hospitalisés				

Questions pour le radiodiagnostic et radiologie interventionnelle

8. Dans quelle(s) modalité(s) exercez-vous ? *(Plusieurs réponses possibles)*
   - ☐ Radiologie conventionnelle
   - ☐ CT
   - ☐ IRM
   - ☐ Mammographie
   - ☐ Ultrasons
   - ☐ Radiologie interventionnelle
   - ☐ Autres activité (Ex: gestion, recherche, formation, expertise)

9. Lors de votre dernière semaine de travail, combien de jours avez-vous travaillé dans chacune des modalités suivantes:

Modalité/activité	Nombre de jours														
Rx conventionnelle	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
CT	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
IRM	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Mammographie	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Ultrasons	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Radiologie interventionnelle	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Autres activités (Ex : gestion, formation, recherche, expertise, …)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7

Questions pour la médecine nucléaire

10. Dans quelle(s) modalité(s) exercez-vous ? *(Plusieurs réponses possibles)*
    - ☐ SPECT (gamma-caméra)
    - ☐ PET
    - ☐ Préparation en laboratoire
    - ☐ Autres activité (Ex: gestion, recherche, formation, expertise)

11. Lors de votre dernière semaine de travail, combien de jours avez-vous travaillé dans chacune des modalités suivantes:

Modalité/activité	Nombre de jours														
SPECT (gamma-caméra)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
PET	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Préparation en laboratoire	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Autres activité (Ex: gestion, recherche, formation, expertise)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7

Questions pour la radiothérapie

12. Dans quelle(s) modalité(s) exercez-vous ?
    - ☐ Machine de traitement
    - ☐ CT/IRM de simulation
    - ☐ Dosimétrie
    - ☐ Autres activité (Ex: gestion, recherche, formation, expertise)

13. Lors de votre dernière semaine de travail, combien de jours avez-vous travaillé dans chacune des modalités suivantes :

Modalité/activité	Nombre de jours														
Machine de traitement	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
CT/IRM de simulation	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Dosimétrie	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Autres activités (Ex: gestion, formation, recherche, expertise)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7

C - TROUBLES MUSCULO-SQUELETTIQUE

Les troubles musculo-squelettiques liés au travail se rapportent aux affections du système musculo-squelettique (courbatures, douleurs ou gênes) causées ou aggravées par l'activité professionnelle ou l'environnement de travail. Le système musculo-squelettique inclus les muscles, les articulations, les tendons, les ligaments, les nerfs, les os et le système vasculaire local.

Le questionnaire ci-dessous est inspiré d'une adaptation française du Questionnaire Nordique (Forcier et al., 2001). Les figures utilisées représentent différentes régions anatomiques considérées dans ce questionnaire. Les limites des régions anatomiques ne sont pas définies d'une manière précise et certaines régions se chevauchent. À vous de décider dans quelle(s) région(s) anatomique(s) se situe(nt) les problèmes que vous ressentez ou que vous avez ressentis.

Issu du Questionnaire Nordique développé par Kuorinka, I., Jonsson, B., Kilbom, A, Vinterberg, H., Biering-Sørensen, F., Andersson, G., Jørgensen, K., adapté par Lina Forcier, Claire Lapointe, Sylvie Beaugrand, Monique Lortie, Ilkka Kuorinka, Peter Buckle, University of Surrey (2001). Consulté à l'adresse http://www.irsst.qc.ca/media/documents/pubirsst/rg1-270.pdf?i=0&redirected=1

1. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) à la nuque ? ☐ Oui ☐ Non	1.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 1.2. Si oui, combien de jours : _____	1.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 1.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 1.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7
2. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) aux épaules (d'un côté ou des deux côtés) ? ☐ Oui ☐ Non	2.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 2.2. Si oui, combien de jours : _____	2.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 2.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 2.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7
3. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) aux coudes (d'un côté ou des deux côtés) ? ☐ Oui ☐ Non	3.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 3.2. Si oui, combien de jours : _____	3.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 3.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 3.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7
4. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) aux poignets/mains (d'un côté ou des deux côtés) ? ☐ Oui ☐ Non	4.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 4.2. Si oui, combien de jours : _____	4.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 4.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 4.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7
5. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) dans le haut du dos (région dorsale) ? ☐ Oui ☐ Non	5.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 5.2. Si oui, combien de jours : _____	5.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 5.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 5.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7

6. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) dans le bas du dos (région lombaire) ? ☐ Oui ☐ Non	6.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 6.2. Si oui, combien de jours : _____	6.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 6.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 6.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7
7. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) aux hanches/cuisses (d'un côté ou des deux côtés) ? ☐ Oui ☐ Non	7.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 7.2. Si oui, combien de jours : _____	7.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 7.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 7.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7
8. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) genoux (d'un côté ou des deux côtés) ? ☐ Oui ☐ Non	8.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 8.2. Si oui, combien de jours : _____	8.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 8.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 8.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7
9. Avez-vous eu, au cours des 12 derniers mois, des problèmes (courbatures, douleurs, gênes) aux pieds/chevilles (d'un côté ou des deux côtés) ?	9.1. Est-ce que ce problème a engendré un arrêt de travail au cours des 12 derniers mois? ☐ Oui ☐ Non 9.2. Si oui, combien de jours : _____	9.3. Avez-vous eu ce problème au cours des 7 derniers jours ? ☐ Oui ☐ Non 9.4. Évaluez le pic d'intensité de ce problème au cours des derniers 7 jours. Intensité 0 1 2 3 4 5 6 7 8 9 10 9.5. Évaluez la fréquence de ce problème au cours des 7 derniers jours. Fréquence 0 1 2 3 4 5 6 7

10. Dans votre activité professionnelle actuelle, associez-vous une/des modalité(s) à vos problèmes (courbatures, douleurs, gênes) ?

- ☐ Oui
- ☐ Non

Questions pour le radiodiagnostic et radiologie interventionnelle

10.1. En radiologie conventionnelle, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.2. Au CT, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.3. En IRM, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.4. En mammographie, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.5. Aux ultrasons, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.6. En radiologie interventionnelle, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

Questions pour la médecine nucléaire

10.7. Au SPECT (gamma caméra), quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.8. Au PET, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.9. Lors de la préparation en laboratoire, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

Questions pour la radiothérapie

10.10. A la machine de traitement, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.11. Au CT/IRM de simulation, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ? (En plus des 9 régions anatomiques, vous avez la possibilité de répondre "N'exerce pas cette modalité", "Ne sais pas" et "Aucune région anatomique".)

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.12. En dosimétrie, quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ?

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

10.13. Lors d'autres activités (ex : gestion, formation, recherche, …), quelle est la région anatomique la plus touchée par vos problèmes (courbatures, douleurs, gênes) ?

- ☐ N'exerce pas cette modalité
- ☐ Ne sais pas
- ☐ Aucune région anatomique
- ☐ Nuque
- ☐ Épaule(s)
- ☐ Coude(s)
- ☐ Poignet(s)/main(s)
- ☐ Haut du dos
- ☐ Bas du dos
- ☐ Hanche(s)/cuisse(s)
- ☐ Genou(x)
- ☐ Cheville(s)/Pied(s)

D - FACTEURS PHYSIQUES

1. Évaluez la fréquence des contraintes suivantes dans votre activité professionnelle actuelle.

	Jamais	Parfois	Souvent	Tout le temps	Ne sais pas	Ne s'applique pas
Je prends des postures inconfortables pour réaliser mon travail (Ex : flexion, extension, torsion)						
Ma force musculaire est requise pour la réalisation mon travail (Ex : transfert de patient, tablier plombé, appareils mobiles).						
Je réalise mon travail en position statique prolongée (Ex : assis, debout).						
Mon travail nécessite des gestes et mouvement répétitifs ou continus.						
Je réalise des déplacements longs et/ou nombreux (Ex : entre salles d'examen, entre services).						

2. Évaluez l'adéquation de votre environnement de travail par rapport à votre activité professionnelle actuelle.

	Totalement inadéquat	Plutôt inadéquat	Plutôt adéquat	Totalement adéquat	Ne sais pas	Ne s'applique pas
Environnement physique (Ex : éclairage, bruit, température).						
Agencement du service (Ex : disposition géographique des salles d'examens et salles de commande).						
Espace de travail (Ex : aménagement des salles, aménagement du poste de commande).						
Appareils radiologiques (Ex : tube Rx, scanner, table d'examen/traitement, mobylette).						
Accessoires radiologiques et d'imagerie (Ex : antennes, casettes, supports, mallettes)						
Équipement informatique (Ex : écrans, consoles, logiciels)						
Mobilier (Ex : tables, chaises)						

E - FACTEURS ORGANISATIONNELS ET PSYCHOSOCIAUX

1. Évaluez quels sont les facteurs psychosociaux suivants présents dans votre activité professionnelle actuelle

	Totalement en désaccord	Plutôt en désaccord	Plutôt en accord	Totalement en accord	Ne sais pas	Ne s'applique pas
Je suis soumis(e) à un rythme de travail soutenu.						
J'ai assez de temps à disposition pour réaliser le volume de travail qui m'est demandé.						
Mon activité professionnelle nécessite ma pleine attention.						
J'ai de l'autonomie dans mon activité professionnelle (Ex : marge de manœuvre, prise de décision).						
J'ai de bonnes relations avec mon hiérarchie (Ex : soutien, ouverture à la discussion).						
J'ai de bonnes relations avec mes collègues TRM (Ex : soutien, confiance, entraide).						
J'ai de bonnes relations avec les autres professionnels de la santé (Ex : soutien, confiance, entraide).						
Je ressens de l'angoisse et/ou du stress lorsque j'exercez mon activité professionnelle.						
Je suis satisfait(e) de mon activité professionnelle.						

F - REMARQUES ET COMMENTAIRES

1. Avez-vous des remarques ou des commentaires sur cette enquête ? (Question optionnelle)

_____ (texte libre)

Je vous remercie pour le temps que vous avez accordé à cette enquête !

Afin que les résultats de l'étude restent intègres, veuillez répondre une seule fois à cette enquête.

Kelly Fernandes

APPENDIX II - SURVEY ENCLOSURE LETTER

Madame, Monsieur,

Je suis actuellement étudiante en Master en Sciences de la Santé, orientation technique en radiologie médicale, formation conjointement offerte par la Haute École Spécialisée de Suisse Occidentale (HES-SO) et l'Université de Lausanne (UNIL). L'enquête à laquelle vous êtes invités à participer s'inscrit dans le cadre d'un travail de Master en vue de l'obtention de mon diplôme.

Cette enquête s'adresse aux technicien-ne-s en radiologie médicale (TRM) travaillant en Suisse romande. La participation à cette enquête est ainsi ouverte à tous les TRM diplômés exerçant dans les différents domaines de la radiologie (radiodiagnostic et radiologie interventionnelle, médecine nucléaire et radiothérapie).

Le but de cette recherche est de dresser un portrait des troubles musculo-squelettiques liés au travail chez les TRM. Les troubles musculo-squelettiques liés au travail se rapportent aux affections du système musculo-squelettique (courbatures, douleurs ou gênes) causées ou aggravées par l'activité professionnelle ou l'environnement de travail. L'enquête permettra d'évaluer la prévalence des symptômes dans les différentes régions anatomiques, ainsi que d'identifier des associations avec des facteurs de risque.

Cette enquête prendra entre 10 et 20 minutes pour être complétée. Il n'est pas possible de l'interrompre momentanément et d'y revenir ultérieurement.

La participation à cette enquête est volontaire, vous êtes libre d'y participer ou non. Vous pouvez à tout moment vous retirer de l'étude en interrompant et en quittant l'enquête. Seules les enquêtes complétées et envoyées seront analysées. Vous ne recevrez aucune rémunération suite à la participation à cette enquête et aucun risque lié à la participation n'a été relevé.

Les réponses fournies sont anonymes et seront traitées de façon confidentielle. Seule l'auteure et un nombre limité de personnes1 auront accès aux données récoltées et exclusivement afin de répondre aux objectifs de recherche.

Ces données seront stockées sur l'ordinateur personnel de l'auteure conformément à l'art. 5 de l'Ordonnance relative à la recherche sur l'être humain et sécurisées par un mot-de-passe. A l'aboutissement de ce travail, les données récoltées seront conservées (conformément aux conditions citées précédemment) et pourraient être exploitées ou transmises à des tiers à des fins de recherche.

Les résultats issus de cette recherche seront toujours présentés sous forme d'un ensemble ne permettant à aucun moment d'identifier les participants. Les résultats seront exposés dans le travail de Master et pourraient être présentés publiquement et/ou publiés dans un cadre scientifique.

Cette recherche pourrait permettre de mettre en évidence l'importance de la prise en compte de la santé et de la sécurité des TRM et donner lieu à des améliorations des conditions de travail dans les services de radiologie. Votre participation et l'honnêteté des réponses sont, par conséquent, essentielles à la qualité des résultats.

Pour toute question concernant l'enquête ou le projet de recherche, n'hésitez pas à prendre contact à l'adresse e-mail suivante : kelly.fernandes@master.hes-so.ch

Je vous remercie d'avance pour votre participation à cette enquête.

Kelly Fernandes

1 Superviseurs du travail de Master et statisticien.

APPENDIX III - INDEPENDENT VARIABLES TESTED IN ASSOCIATIVE ANALYSIS

Table 11 - Variables assessed in survey analysis to explore associations between WRMSDs symptoms and risk factors.

Individual factors	Sex Age Diseases
Professional background factors	Radiological field Years of experience
Ergonomic factors	Awkward posture Physical force Static posture Repetitive movements Long/numerous reaches
Physical factors	Physical environment Service layout Workspace Radiological equipment Radiological accessories IT Furnitures
Organizational and psychosocial factors	Work pace Time to complete the volume of work Attention required in work activities Autonomy in professional activity Rapports with hierarchy Rapports with other radiographers Rapports with healthcare workers Feeling of anxiety/stress Satisfied with professional activity

APPENDIX IV - SIMULATION INFORMATION AND CONSENT FORM

Titre du projet de recherche

Troubles musculo-squelettiques liés au travail chez les TRM de Suisse romande.

WRMDs among radiographers of Western Switzerland: prevalence, risk factors and posture assessment.

Ce projet est organisé par : Cláudia Sá dos Reis

Madame, Monsieur,

Nous vous proposons de participer à notre projet de recherche. Cette feuille d'information décrit le projet de recherche.

1. Objectifs du projet de recherche

L'objectif de ce projet de recherche est d'étudier les troubles musculo-squelettiques liés au travail chez les Technicien-ne-s en Radiologie Médicale (TRM). Ces troubles peuvent être provoqués ou aggravés par les activités et l'environnement professionnel. Le domaine médical implique souvent une importante demande physique et mentale ainsi que du stress. Ces contraintes peuvent affecter la sécurité et la santé du professionnel et engendrer des troubles musculo-squelettiques. Parmi les maladies et blessures liées au travail, les troubles musculo-squelettiques sont largement représentés chez les professionnels de santé et notamment chez les TRM. La prévalence des troubles musculo-squelettiques liés au travail chez les TRM oscille entre 60% et 93% en fonction du domaine et de la modalité exercée.

Les objectifs de cette étude sont de déterminer la prévalence des troubles musculo-squelettiques chez les TRM, d'identifier les facteurs de risque associés à ces troubles dans une première phase, et d'analyser les postures adoptées par les TRM lors de la manipulation de l'équipement et du positionnement, dans une deuxième phase.

2. Sélection des personnes pouvant participer au projet

La participation est ouverte à tous-tes les technicien-ne-s en radiologie médicale diplômé-e-s réalisant des radiographies de thorax au lit en salle de radiographie conventionnelle et travaillant dans les départements de radiologie du Centre Hospitalier Universitaire Vaudois.

Les TRM souffrant de maladies (chroniques ou aiguës), traumatismes, ainsi que les TRM enceintes au moment de la récolte de données seront exclus de ce projet de recherche.

3. Informations générales sur le projet

Cette étude s'inscrit dans le cadre du Master en Sciences de la Santé de la Haute École Spécialisée de Suisse Occidentale (HES-SO), orientation Technique en radiologie médicale et l'Université de Lausanne, orientation Technique en radiologie médicale. Ce projet prendra fin en décembre 2020.

Ce projet d'ordre régional vise à étudier les TRM de façon exploratoire en deux phases ; une enquête et des observations sur le terrain. Ce type d'approche a été choisi dû au faible nombre d'études impliquant les TRM de tous les domaines de la radiologie et s'intéressant aux postures adoptées pendant leurs activités professionnelles.

Dans la première phase, une enquête en ligne a permis de récolter des données sur la prévalence et les facteurs de risque associés aux troubles musculo-squelettiques Vous êtes maintenant invités à participer à la deuxième phase de cette étude qui consiste à analyser les postures adoptées par les TRM lors de la

manipulation de l'équipement et du positionnement. Cinq participants seront inclus dans cette phase de simulation.

Nous effectuons ce projet dans le respect des prescriptions de la législation suisse. La commission cantonale d'éthique compétente a contrôlé et autorisé le projet.

4. Déroulement pour les participants

Des observations seront menées dans le service de radiologie afin de suivre le TRM dans son activité professionnelle. Une analyse des postures adoptées par les TRM lors de la manipulation de l'équipement et du positionnement sera réalisée. Cette analyse s'intéressera aux postures des TRM lors de la réalisation de radiographies du thorax au lit.

L'observation séquentielle permettra de caractériser les pratiques au travers de l'identification des différentes tâches réalisées. Le temps nécessaire pour réaliser les différentes activitées lors de cet examen seront également enregistrés. Des notes descriptives et des représentations graphiques seront également utilisées afin de reproduire au mieux les situations lors des simulations.

Des simulations des postures les plus exigeantes et seront ensuite réalisées et filmées afin d'évaluer les variations posturales des principaux segments du corps (tête/cou, bras et tronc). Les séquences filmées ont pour unique intérêt l'analyse de la posture lors de la manipulation du matériel radiologique et du positionnement. Pour cela, des prises de vues latérales et postérieures seront réalisées.

Les observations et simulations prendrons place sur votre lieu de travail. Vous serez observés pendant vos heures de travail dans votre activité professionnelle lors de radiographies de thorax au lit réalisés en salle de radiologie conventionnelle au BH07 et au BH05. Les séquences filmées lors des simulations prendront quant à elles environ une heure et seront réalisés en dehors de vos heures de travail.

5. Bénéfices pour les participants

Votre participation au projet ne vous apportera aucun bénéfice direct. Néanmoins, les résultats peuvent fournir des clés aux chefs TRM et aux institutions leur permettant de faire de la prévention et d'améliorer les conditions de travail afin de réduire la prévalence des troubles musculo-squelettiques chez les TRM.

6. Droits des participants

Vous êtes libre d'accepter ou de refuser de participer au projet. Si vous choisissez de ne pas participer ou si vous choisissez de participer et revenez sur votre décision pendant le déroulement du projet, vous n'aurez pas à vous justifier. Vous pouvez à tout moment poser toutes les questions nécessaires au sujet de l'étude. Veuillez-vous adresser pour ce faire à la personne indiquée à la fin de la présente feuille d'information.

7. Risques

Les risques associés à ce projet d'étude sont minimes. Les données sur la santé seront recueillies par le biais d'observations et de simulations. Ces méthodes sont considérées comme des risques et des charges minimes selon l'article 7 de l'Ordonnance relative à la recherche sur l'être humain (ORH).

8. Confidentialité des données

Pour les besoins de l'étude, nous enregistrerons vos données personnelles. Seul un nombre limité de personnes peut consulter vos données sous une forme non codée, et exclusivement afin de pouvoir accomplir des tâches nécessaires au déroulement du projet.

Les images enregistrées durant les simulations seront effacées de la carte mémoire de l'appareil photo une fois les images transférées sur l'ordinateur personnel de l'auteure. Les temps par activité, les angles du corps observés, ainsi que les images enregistrées seront attribués au TRM observé sous forme codée. L'ensemble des données récoltées et les images enregistrées seront stockés sur l'ordinateur personnel de l'auteure conformément à l'article 5 de l'Ordonnance relative à la recherche sur l'être humain et sécurisé par un mot-de-passe.

Les prises de vues latérales et postérieures les angles du corps pourront être réutilisées dans le travail de master ou des publications afin d'illustrer les postures adoptées lors de la réalisation de radiographies de thorax au lit. Afin de garantir l'anonymat, votre visage sera flouté sur toute les images utilisées.

Afin d'assurer la confidentialité des données, les informations recueillies seront codées. Les personnes ne connaissant pas ce code ne peuvent pas lier ces données à votre personne. Dans le cas d'une publication, les données agrégées ne vous sont donc pas imputables en tant que personne. Votre nom n'apparaîtra jamais sur Internet ou dans une publication. Parfois, les journaux scientifiques exigent la transmission de données individuelles (données brutes). Si des données individuelles doivent être transmises, elles sont toujours codées et ne permettent donc pas de vous identifier en tant que personne. Toutes les personnes impliquées dans l'étude de quelque manière que ce soit sont tenues au secret professionnel. Toutes les directives relatives à la protection des données sont respectées et vous avez à tout moment le droit de consulter vos données.

Il se peut que les données liées à votre santé soient ultérieurement exploitées dans de futurs projets de recherches ou envoyées pour être aussi exploitées dans d'autres projets de recherche. Pour cette réutilisation, nous vous prions de signer un consentement séparé à la fin de cette feuille d'information.

Durant son déroulement, le projet peut faire l'objet d'inspections. Celles-ci peuvent être effectuées par la commission d'éthique qui s'est chargée de son contrôle initial et l'a autorisé, mais aussi être mandatées par l'organisme qui l'a initié. Il se peut que la direction du projet doive communiquer vos données personnelles et de santé pour les besoins de ces inspections.

A l'aboutissement de ce projet de recherche, les temps par activité, les angles du corps mesurés sur les images de simulation, ainsi que les images réalisées lors des simulations seront stockés sur les serveurs informatiques de la Haute École de Santé de Vaud conformément à l'article 5 de l'Ordonnance relative à la recherche sur l'être humain et de façon sécurisée pour une durée de 10 ans.

9. Retrait du projet

Vous pouvez à tout moment vous retirer de l'étude si vous le souhaitez. Les données de santé recueillies jusque-là seront tout de même analysés, ceci afin de ne pas compromettre la valeur de l'étude dans son ensemble.

Après l'analyse nous rendrons vos données anonymes, en effaçant définitivement le code les reliant à votre personne et nous détruirons les séquences filmées. Après cela, plus personne ne pourra savoir que ces données et ce matériel sont les vôtres.

10. Rémunération des participants

Si vous participez à ce projet, vous ne recevrez pour cela aucune rémunération. Votre participation n'aura aucune conséquence financière pour vous.

11. Réparation des dommages subis

Les dommages de santé que vous pourriez subir du fait de cette étude relèvent de la responsabilité de HESAV qui l'a initiée et est en charge de sa réalisation. Les conditions et la procédure sont fixées par la loi. Si vous avez subi un dommage, veuillez-vous adresser à la direction du projet.

12. Financement du projet

Cette étude n'est pas financée.

13. Interlocuteur(s)

En cas de doute, de craintes ou d'urgences pendant ou après l'étude, vous pouvez vous adresser à tout moment à l'un des interlocuteurs suivants :

Responsable du projet : Dr. Cláudia Sá dos Reis, Professeure HES, Haute École de Santé de Vaud (HESAV), Avenue de Beaumont 21, 1011 Lausanne, (+41) 021/316.81.43, claudia.sadosreis@hesav.ch

Collaborateurs : Kelly Fernandes, Étudiante MScSa, (+41) 076/337.02.10, kelly.fernandes@master.hes-so.ch

Déclaration de consentement

Déclaration de consentement écrite pour la participation à un projet de recherche

- Veuillez lire attentivement ce formulaire.
- N'hésitez pas à poser des questions lorsque vous ne comprenez pas quelque chose ou que vous souhaitez avoir des précisions.

Numéro BASEC du projet : (après soumission à la commission d'éthique compétente) :	2020-01174
Titre de l'étude : (titre scientifique et titre usuel)	WRMDs among radiographers of Western Switzerland: prevalence, risk factors and posture assessment. Troubles musculo-squelettiques liés au travail chez les TRM de Suisse romande.
Institution responsable : (adresse complète) :	Haute École de Santé de Vaud (HESAV), Avenue de Beaumont 21, 1011 Lausanne
Lieu de réalisation du projet :	Centre Hospitalier Universitaire Vaudois
Directeur / directrice du projet sur le site : (nom et prénom en caractères d'imprimerie) :	Dr. Cláudia Sá dos Reis
Participant / participante : (nom et prénom en caractères d'imprimerie) : Date de naissance :	☐ femme ☐ homme

- Je déclare avoir été informé, par la personne soussigné(e) assurant l'information, oralement et par écrit, des objectifs et du déroulement du projet ainsi que des effets présumés, des avantages, des inconvénients possibles et des risques éventuels.
- Je prends part à cette étude de façon volontaire et j'accepte le contenu de la feuille d'information qui m'a été remise sur le projet précité. J'ai eu suffisamment de temps pour prendre ma décision.
- J'ai reçu des réponses satisfaisantes aux questions que j'ai posées en relation avec ma participation au projet. Je conserve la feuille d'information et reçois une copie de ma déclaration de consentement écrite.
- J'accepte que les spécialistes compétents de l'institution, du mandataire du projet, de la Commission d'éthique compétente pour cette étude, puissent consulter mes données brutes afin de procéder à des contrôles, à condition toutefois que la confidentialité de ces données soit strictement assurée.
- Je sais que mes données personnelles peuvent être transmises à des fins de recherche **dans le cadre de ce projet uniquement** et sous une forme codée aussi à l'étranger.
- Je peux, à tout moment et sans avoir à me justifier, révoquer mon consentement à participer à l'étude, sans que cela n'ait de répercussion défavorable. Je sais que les données de santé qui ont été recueillies jusque-là seront cependant analysés.
- Je suis informé que la responsabilité civile de HESAV couvre les dommages éventuels imputables au projet que je pourrais subir.

Lausanne, 05 novembre 2020	Signature du participant / de la participante

Attestation de la personne assurant l'information : Par la présente, j'atteste avoir expliqué au participant / à la participante la nature, l'importance et la portée du projet. Je déclare satisfaire à toutes les obligations en relation avec ce projet conformément au droit en vigueur. Si je devais prendre connaissance, à quelque moment que ce soit durant la réalisation du projet, d'éléments susceptibles d'influer sur le consentement du participant / de la participante à prendre part au projet, je m'engage à l'en informer immédiatement.

Lausanne, 05 novembre 2020	Kelly Fernandes Signature de la personne assurant l'information

Déclaration de consentement écrite pour la réutilisation de données sous une forme codée

Numéro BASEC du projet :	2020-01174
Titre de l'étude : (titre scientifique et titre usuel)	WRMSDs among radiographers of Western Switzerland: prevalence, risk factor and posture assessment. Troubles musculo-squelettiques liés au travail chez les TRM de Suisse romande.
Participant / participante : (nom et prénom en caractères d'imprimerie) : Date de naissance :	 ☐ femme ☐ homme

- J'accepte que mes données obtenues dans le cadre de ce projet puissent être réutilisés à des fins de recherche médicale. Cela signifie que les données de santé seront conservées et ultérieurement exploité pour une durée indéfinie dans le cadre de futurs projets de recherche. Le présent consentement a une durée de validité illimitée.
- Je donne mon accord de façon volontaire et je peux à tout moment revenir sur ma décision. Si je reviens sur ma décision, mes données seront rendues anonymes. Je dois simplement en informer la direction du projet. Je n'ai pas à justifier ma décision.
- Je sais que mes données sont conservées sous forme codée et que la liste d'identification est gardée dans un lieu sûr. Je sais que les données peuvent être envoyées à des fins d'analyse en Suisse ou à l'étranger, à condition qu'elle obéisse à des normes et exigences au moins équivalentes aux normes et exigences suisses. Toutes les dispositions légales relatives à la protection des données sont respectées.
- Généralement, les données sont exploitées de manière globale et les résultats sont publiés de manière synthétique.
- Je renonce à tout droit d'exploitation commerciale sur mes données.

Lausanne, 05 novembre 2020	Signature du participant / de la participante

Attestation de la personne assurant l'information : Par la présente, j'atteste avoir expliqué au participant / à la participante la nature, l'importance et la portée de la réutilisation des données.

Lausanne, 05 novembre 2020	Kelly Fernandes Signature de la personne assurant l'information

APPENDIX V - OBSERVATION CASE REPORT FORM

	Temps/activité (sec)							
Activités	*Obs. 1*	*Obs. 2*	*Obs. 3*	*Obs. 4*	*Obs. 5*	*Obs. 6*	*Obs. 7*	*Obs. 8*
Manutention du patient								
Positionnement du détecteur								
Control du positionnement du détecteur								
Manipulation du tube à rayons-x								
Acquisition cliché								
Retrait du tube à rayons-X								
Manutention du patient								
Retrait du détecteur								
Temps total (min:sec)								
Remarques								

Obs. = Observation

APPENDIX VI - SURVEY DESCRIPTIVE RESULTS

Table 12 - Individual and lifestyle characteristics of the participants.

Characteristics ▿	Categories	N	%
Gender (N=359)	Female	232	64.6%
	Male	127	35.4%
Age (n=354)	20-29 yo	77	21,4%
	30-39 yo	118	32,9%
	40-49 yo	71	19,8%
	50-59 yo	72	20,1%
	60 yo and more	16	4,5%
BMI (n=354)	Underweight (<18.5)	9	2.5%
	Normal weight (18.5-24.9)	233	65.3%
	Pre-obesity (25.0-29.9)	95	26.6%
	Obesity (≥30)	20	5.6%
Smoker status (N=359)	Non-smoker	275	76.6%
	Smoker	84	23.4%
Alcohol (N=359)	Less or equal to recommendations	351	97.8%
	More than recommendations	8	2.2%
Coffined/energy drink (N=359)	≤ 2/day	202	56.3%
	> 2/day	157	43.7%
Regular exercise activity (N=359)	No	129	35.9%
	Yes	230	64,1%

▿*Due to missing values, all variables could not be assessed for all the participants.*

Table 13 - General health characteristics of the participants.

Characteristics ▿	Categories	N	%
General health status (N=359)	Very good	79	22.0%
	Good	226	63.0%
	Moderate	45	12.5%
	Bad	8	2.2%
	Very bad	1	2.3%
Pain medication intake in last 7 days (N=359)	Yes	110	30.6%
	No	249	69.4%
Medical appointments (N=359)	≤ 4	75	28.9%
	> 4	284	79.1%
Rehabilitation treatment (N=359)	Yes	43	12.0%
	No	316	88.0%
Diseases or health disorders (N=359)	Yes	111	30.9%
	No	248	69.1%
Number or morbidities (n=111)	1	38	34,2%
	2	39	35,1%
	3	16	14,4%
	4	10	9,0%
	5	5	4,5%
	6	2	1,8%
	7	0	0,0%
	8	1	0,9%
Diseases or health disorders affect musculoskeletal system (n=111)	Yes	76	68.5%
	No	35	31.5%
MSDs symptoms related to another health problem are caused/aggravated by work (n=76)	Yes	63	82.9%
	No	13	17.1%

▿*Due to missing values, all variables could not be assessed for all the participants.*

Table 14 - Professional background of the participants.

Characteristics		N	%
Years of experience (N=359)	≤ 5 years	94	26.2%
	6-10 years	58	16.2%
	11-15 years	56	15.6%
	16-20 years	40	11.1%
	> 20 years	111	30.9%
Radiographers' function(s) (N=359)	Radiographer	245	68.3%
	Radiographer & other function(s)	114	31.7%
Years in the actual institution (N=359)	≤ 5 years	152	42.3%
	6-10 years	63	17.6%
	11-15 years	50	13.9%
	16-20 years	28	7.8%
	> 20 years	66	18.4%
Institution type (N=359)	Public & university	127	35,4%
	Public & non-university	142	39.5%
	Private / Semi-private	90	25.1%
Working percentage (N=359)	100%	187	52,1%
	90%	30	8,4%
	80%	59	16,4%
	70%	20	5,6%
	60%	51	14,2%
	50%	10	2,8%
	40%	2	0,6%
Frequency of dayshifts (N=359)	Never / Sometimes	6	1.7%
	Often / All the time	353	98.3%
Frequency of nightshifts (N=359)	Never / Sometimes	287	79.9%
	Often / All the time	72	20.1%
Frequency of on-call (N=359)	Never / Sometimes	325	90.5%
	Often / All the time	34	9.5%
Frequency of outpatient (N=359)	Never / Sometimes	18	5.0%
	Often / All the time	341	95.0%
Frequency of inpatients (N=359)	Never / Sometimes	101	28.1%
	Often / All the time	258	71%

Table 15 - Effective distribution of participants by imaging modality.

Radiological fields	Modalities	N
Diagnostics and Interventional Radiography (n=265) [a]	Conventional radiology	242
	CT	192
	MRI	152
	Mammography	95
	Ultrasounds	99
	Interventional radiology	96
	Other in DIR	50
Nuclear Medicine (n=35) [a]	SPECT	34
	PET	34
	Laboratory	24
	Other in MN	18
Radiotherapy (n=59) [a]	Treatment machine	55
	CT/MRI simulation	41
	Dosimetry	23
	Other in RT	15

[a] *Participants may be in more than one imaging modality.*

Table 16 - Detailed mode scores per statement of biomechanical and physical risk factors.

Statements	Mode of scores			
	DIR	*MN*	*RT*	*All radiological fields*
Ergonomic factors				
Awkward posture	2	3	3	2
Physical force	3	3	3	3
Static posture	3	2	3	3
Repetitive movements	3	3	4	3
Long/numerous reaches	3	4	3	3
Physical factors				
Physical environment	3	3	3	3
Service layout	3	3	3	3
Workspace	3	3	3	3
Radiological equipment	3	3	3	3
Radiological accessories	3	3	3	3
IT	3	3	3	3
Furnitures	3	3	3	3

Table 17 - Detailed mode scores per statement of organizational and psychosocial risk factors.

Statements	Mode of scores			
	DIR	*MN*	*RT*	*All radiological fields*
I am subject to a sustained work pace.	1*	2*	2*	2*
I have enough time to complete the volume of work.	3	2	3	3
My professional activity requires my full attention.	1*	1*	1*	1*
I have autonomy in my professional activity.	3	3	3	3
I have good rapports with my hierarchy.	3	3	4	3
I have good rapports with other radiographers (colleagues).	4	4	4	4
I have good rapports with other healthcare workers.	3	3	3	3
I feel anxiety and/or stress when I exercise my professional activity.	3*	3*	3*	3*
I am satisfied with my professional activity.	3	3	3	3

** Corrected scores corresponding to inverted coding due to wording nature of statements.*

Table 18 - Prevalence of WRMSDs symptoms in the last 12 months by radiological fields and by anatomical regions.

Anatomical region	DIR (n=265)		MN (n=35)		RT (n=59)		For all radiological fields (N=359)	
	Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*	*Freq.*	*%*
Neck	196	74.0%	24	68.6%	42	71.2%	262	73.0%
Upper back	123	46.4%	16	45.7%	22	37.3%	161	44.9%
Lower back	187	70.6%	20	57.1%	35	59.3%	242	67.4%
Shoulders	150	56.6%	17	48.6%	33	55.9%	200	55.7%
Elbows	40	15.1%	8	22.9%	11	18.6%	59	16.4%
Wrists/Hands	67	25.3%	11	31.4%	13	22.0%	91	25.4%
Hips/thighs	37	14.0%	4	11.4%	13	22.0%	54	15.0%
Knees	59	22.3%	10	28.6%	16	27.1%	85	23.7%
Feet	62	23.4%	8	22.9%	8	13.5%	78	21.7%
Any region	252	95.1%	33	94.3%	55	93.2%	340	94.7%

[a] *Total of participants by radiological field: DIR (n=265), MN (n=35), RT (n=59), All radiological fields (N=359).*

Table 19 - Prevalence of WRMSDs symptoms in the last 7 days by radiological fields and by anatomical regions.

Anatomical region	DIR (n=265)		MN (n=35)		RT (n=59)		For all radiological fields (N=359)	
	Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*	*Freq.*	*%*
Neck	102	38.5%	11	31.4%	19	32.2%	132	36.8%
Upper back	61	23.0%	8	22.9%	11	18.6%	80	22.3%
Lower back	100	37.7%	11	31.4%	17	28.8%	128	35.7%
Shoulders	57	21.5%	9	25.7%	12	20.3%	78	21.7%
Elbows	19	7.2%	2	5.7%	7	11.9%	28	7.8%
Wrists/Hands	29	10.9%	3	8.6%	9	15.4%	41	11.4%
Hips/Thighs	20	7.5%	2	5.7%	9	15.3%	31	8.6%
Knees	34	12.8%	8	22.9%	10	16.9%	52	14.5%
Ankles/Feet	38	14.3%	3	8.6%	5	8.5%	46	12.8%
Any region	183	69.1%	24	68.6%	36	61.0%	243	67.7%

Table 20 - Relative frequencies of work absence in last 12 months in radiographers and median length of work absence in radiographers reporting WRMSDs symptoms in last 12 months, by radiological field and anatomical region.

Anatomical region	DIR (n=265)		MN (n=35)		RT (n=59)		For all radiological fields (N=359)	
	%	*Mean ± SD (days)*	%	*Mean ± SD (days)*	%	*Mean ± SD (days)*	%	*Mean ± SD (days)*
Neck	2.3%	104 ± 131	5.7%	7 ± 0	1.7%	18 ± 0	2.5%	73 ± 114
Upper back	2.3%	25 ± 33	2.9%	7 ± 0	5.1%	7 ± 9	2.8%	18 ± 27
Lower back	4.9%	77 ± 132	11.4%	8 ± 9	11.9%	12 ± 13	6.7%	47 ± 102
Shoulders	2.3%	118 ± 144	5.7%	33 ± 37	0.0%	-	2.2%	97 ± 129
Elbows	1.1%	202 ± 154	0.0%	-	0.0%	-	0.8%	202 ± 154
Wrists/Hands	3.0%	111 ± 130	2.9%	20 ± 0	3.4%	15 ± 4	3.1%	85 ± 118
Hips/Thighs	0.8%	44 ± 43	0.0%	-	5.1%	20 ± 18	1.4%	30 ± 28
Knees	1.1%	79 ± 88	2.9%	2 ± 0	1.7%	7 ± 0	1.4%	49 ± 75
Feet	1.5%	107± 173	5.7%	25 ± 15	3.4%	12 ± 8	2.2%	62 ± 123
Any region	12.8%	-	28.6%	-	20.3%	-	15.6%	-

Table 21 - Frequencies (%) and median of pain intensity (NPRS) in last 7 days in in symptomatic radiographers by radiological field and anatomical region.

Anatomical region	NPRS	DIR		MN		RT		For all radiological fields	
		%	*M*	%	*M*	%	*M*	%	*M*
Neck	Mild	25.3%		36.4%		36.8%		35.6%	
	Moderate	44.1%	4	36.4%	5	57.9%	4	45.5%	4
	Severe	20.6%		27.3%		5.3%		18.9%	
Upper back	Mild	34.4%		50.0%		27.3%		35.0%	
	Moderate	54.1%	4	37.5%	3.5	27.3%	6	48.8%	4
	Severe	11.5%		12.5%		45.5%		16.3%	
Lower back	Mild	34.0%		27.3%		17.7%		31.3%	
	Moderate	51.0%	4	54.6%	4	47.1%	6	50.8%	4.5
	Severe	15.0%		18.2%		35.3%		18.0%	
Shoulders	Mild	40.4%		22.2%		25.0%		35.9%	
	Moderate	40.4%	4	55.6%	5	50.0%	5.5	43.6%	5
	Severe	19.3%		22.2%		25.0%		20.5%	
Elbows	Mild	36.8%		50.0%		42.9%		39.3%	
	Moderate	52.6%	4	50.0%	3.5	42.9%	4	50.0%	4
	Severe	10.5%		0.0%		14.3%		10.7%	
Hands/Wrists	Mild	34.5%		33.3%		22.2%		31.7%	
	Moderate	44.8%	5	33.3%	4	33.3%	5	41.5%	5
	Severe	20.7%		33.3%		44.4%		26.8%	
Hips/Thighs	Mild	45.0%		100.0%		33.3%		45.2%	
	Moderate	40.0%	4	0.0%	1.5	55.6%	5	41.9%	4
	Severe	15.0%		0.0%		11.1%		12.9%	
Knees	Mild	52.9%		37.5%		40.0%		48.1%	
	Moderate	38.2%	3	62.5%	4	50.0%	4.5	44.2%	4
	Severe	8.8%		0.0%		10.0%		7.7%	
Feet	Mild	44.7%		100.0%		20.0%		45.7%	
	Moderate	31.6%	4	0.0%	1	60.0%	6	32.6%	4
	Severe	23.7%		0.0%		20.0%		21.7%	

M = Median

Table 22 - Pain frequency in last 7 days in symptomatic radiographers by radiological field and anatomical region.

Anatomical region	Pain frequency (per week)	RDGI		MN		RT		For all radiological fields	
		n	%	*n*	%	*n*	%	*n*	%
Neck	Rarely/ Sometimes	59	57.8%	4	36.4%	10	52.6%	73	55.3%
	Often/ Every day	43	42.2%	7	63.6%	9	47.4%	59	44.7%
Upper back	Rarely/ Sometimes	40	65.6%	5	62.5%	6	54.6%	51	63.8%
	Often/ Every day	21	34.4%	3	37.5%	5	45.5%	29	36.2%
Lower back	Rarely/ Sometimes	57	57.0%	7	63.6%	5	29.4%	69	53.9%
	Often/ Every day	43	43.0%	4	36.4%	12	70.6%	59	46.1%
Shoulders	Rarely/ Sometimes	28	49.1%	3	33.3%	7	58.3%	38	48.7%
	Often/ Every day	29	50.9%	6	66.7%	5	41.7%	40	51.3%
Elbow	Rarely/ Sometimes	7	36.8%	1	50.0%	2	28.6%	10	35.7%
	Often/ Every day	12	63.2%	1	50.0%	5	71.4%	18	64.3%
Wrists/ Hands	Rarely/ Sometimes	11	37.9%	1	33.3%	2	22.2%	14	34.1%
	Often/ Every day	18	62.1%	2	66.7%	7	77.8%	27	65.9%
Hips/ Thighs	Rarely/ Sometimes	9	45.0%	2	100.0%	1	11.1%	12	38.7%
	Often/ Every day	11	55.0%	0	0.0%	8	88.9%	19	61.3%
Knee	Rarely/ Sometimes	20	58.8%	4	50.0%	4	40.0%	28	53.8%
	Often/ Every day	14	41.2%	4	50.0%	6	60.0%	24	46.2%
Ankles/Feet	Rarely/ Sometimes	9	23.7%	1	33.3%	1	20.0%	11	23.9%
	Often/ Every day	29	76.3%	2	66.7%%	4	80.0%	35	76.1%

APPENDIX VII – SURVEY ASSOCIATIVE RESULTS

Table 23 - Results of associative analysis between WRMSDs symptoms in the last 12 months and radiological field by anatomical region.

Anatomical region	Radiological field	OR	95% CI	P-value global test
Neck	RDGI	1.00		
	MN	0.77	0.36 - 1.65	
	RT	0.87	0.46 - 1.63	0.752
Upper back	RDGI	1.00		
	MN	0.97	0.48 - 1.97	
	RT	0.69	0.38 - 1.23	0.442
Lower back	RDGI	1.00		
	MN	0.56	0.27 - 1.15	
	RT	0.61	0.34 - 1.09	0.099
Shoulders	RDGI	1.00		
	MN	0.72	0.36 - 1.47	
	RT	0.97	0.55 - 1.72	0.668
Elbow	RDGI	1.00		
	MN	1.67	0.70 - 3.94	
	RT	1.29	0.62 - 2.70	0.449
Wrists/Hands	RDGI	1.00		
	MN	1.35	0.63 - 2.92	
	RT	0.84	0.42 - 1.64	0.599
Hips	RDGI	1.00		
	MN	0.80	0.26 - 2.39	
	RT	1.74	0.86 - 3.54	0.241
Knee	RDGI	1.00		
	MN	1.40	0.63 - 3.08	
	RT	1.30	0.68 - 2.47	0.566
Ankles/Feet	RDGI	1.00		
	MN	0.97	0.42 - 2.25	
	RT	0.51	0.23 - 1.15	0.251

Table 24 - Results of associative analysis between WRMSDs symptoms in the last 7 days and radiological field by anatomical region.

Anatomical region	Radiological field	OR	95% CI	P value global test
Neck	RDGI	1.00		
	MN	0.78	0.33 - 1.83	
	RT	0.76	0.39 - 1.49	0.652
Upper back	RDGI	1.00		
	MN	1.02	0.36 - 2.89	
	RT	1.02	0.41 - 2.53	0.999
Lower back	RDGI	1.00		
	MN	1.06	0.42 - 2.69	
	RT	0.82	0.40 - 1.70	0.851
Shoulders	RDGI	1.00		
	MN	1.84	0.67 - 5.07	
	RT	0.93	0.43 - 2.04	0.463
Elbow	RDGI	1.00		
	MN	0.37	0.06 - 2.14	
	RT	1.93	0.48 - 7.86	0.256
Wrists/Hands	RDGI	1.00		
	MN	0.49	0.12 - 2.05	
	RT	2.95	0.80 - 10.88	0.105
Hips	RDGI	1.00		
	MN	0.85	0.11 - 6.87	
	RT	1.91	0.49 - 7.52	0.611
Knee	RDGI	1.00		
	MN	2.94	0.56 - 15.58	
	RT	1.23	0.39 - 3.85	0.408
Ankles/Feet	RDGI	1.00		
	MN	0.38	0.08 - 1.78	
	RT	1.05	0.23 - 4.87	0.431

Table 25 - Associative analysis between WRMSDs symptoms in the neck and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	2.15	1.33 - 3.49	0.001*
Physical force	Never/Sometimes	1.00		
	Often/Always	1.44	0.84 - 2.46	0.183
Static postures	Never/Sometimes	1.00		
	Often/Always	1.40	0.88 - 2.24	0.157
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.56	0.97 - 2.52	0.065
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.10	0.68 - 1.76	0.698
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.91	1.13 - 3.25	0.015*
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.54	0.89 - 2.68	0.122
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.82	0.99 - 3.34	0.050*
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.51	0.78 - 2.94	0.221
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.59	0.84 - 3.00	0.152
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.89	0.88 - 4.07	0.096
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.89	1.11 - 3.23	0.018*
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.06	0.52 - 2.17	0.864
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.42	0.88 - 2.28	0.150
Full attention not required to perform work activities	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	8.32	0.65 - 438.85	0.062
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.87	1.03 - 3.39	0.035*
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.37	0.73 - 2.57	0.330
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.38	0.38 - 5.08	0.623
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.81	0.37 - 1.78	0.597
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.43	0.87 - 2.35	0.156
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.08	0.93 - 4.64	0.067
Gender	Men	1.00		
	Women	1.90	1.17 - 3.08	0.008*
Age	20-29 yo	1.00		
	30-39 yo	1.08	0.57 - 2.04	
	40-49 yo	0.89	0.44 - 1.81	
	50-59 yo	1.66	0.77 - 3.59	
	60 yo and more	0.88	0.27 - 2.85	0.478
Diseases or health disorders	No	1.00		
	Yes	2.22	1.26 - 3.92	0.005*
Years of experience	≤ 5 years	1.00		
	6-10 years	1.47	0.68 - 3.15	
	11-15 years	1.16	0.55 - 2.43	
	16-20 years	0.99	0.44 - 2.23	
	> 20 years	1.20	0.65 - 2.22	0.805

** Significant results (p≤0.05).*

Table 26 - Associative analysis between WRMSDs symptoms in the upper back and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.73	1.13 - 2.65	0.011*
Physical force	Never/Sometimes	1.00		
	Often/Always	1.47	0.89 - 2.45	0.131
Static postures	Never/Sometimes	1.00		
	Often/Always	0.95	0.63 - 1.45	0.824
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	0.99	0.64 - 1.51	0.951
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	0.83	0.54 - 1.27	0.385
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.24	0.80 - 1.92	0.340
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.70	1.06 - 2.73	0.025*
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.26	0.78 - 2.06	0.347
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.93	0.54 - 1.63	0.810
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.45	0.86 - 2.44	0.161
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.55	0.86 - 2.81	0.143
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.96	0.62 - 1.49	0.855
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.15	0.61 - 2.20	0.662
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.25	0.82 - 1.90	0.297
Full attention not required to perform work activities	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.81	0.11 - 5.84	0.835
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.36	0.84 - 2.20	0.203
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.65	0.96 - 2.83	0.065
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	4.83	1.31 - 17.88	0.009*
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.46	0.21 - 1.03	0.054
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.67	1.08 - 2.59	0.019*
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.16	1.16 - 4.03	0.013*
Gender	Men	1.00		
	Women	1.34	0.87 - 2.09	0.187
Age	20-29 yo	1.00		
	30-39 yo	0.91	0.51 - 1.62	
	40-49 yo	0.89	0.46 - 1.70	
	50-59 yo	0.82	0.43 - 1.56	
	60 yo and more	0.49	0.15 - 1.57	0.291
Diseases or health disorders	No	1.00		
	Yes	1.07	0.68 - 1.67	0.780
Years of experience	≤ 5 years	1.00		
	6-10 years	0.93	0.48 - 1.80	
	11-15 years	0.56	0.28 - 1.11	
	16-20 years	0.90	0.43 - 1.90	
	> 20 years	0.73	0.42 - 1.28	0.284

* *Significant results (p≤0.05).*

Table 27 - Associative analysis between WRMSDs symptoms in the lower back and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI		P-value global test
Awkward postures	Never/Sometimes	1.00			
	Often/Always	2.86	1.78	4.58	>0.001*
Physical force	Never/Sometimes	1.00			
	Often/Always	2.18	1.30	3.65	0.002*
Static postures	Never/Sometimes	1.00			
	Often/Always	1.08	0.69	1.68	0.742
Repetitive movements	Never/Sometimes	1.00			
	Often/Always	0.97	0.62	1.53	0.905
Long/numerous reaches	Never/Sometimes	1.00			
	Often/Always	0.97	0.62	1.53	0.905
Physical environment	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.54	0.95	2.49	0.079
Service layout	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.52	0.91	2.55	0.110
Workspace	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.22	0.72	2.07	0.462
Radiological equipment	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.93	1.01	3.69	0.042*
Radiological accessories	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	0.93	0.54	1.61	0.795
IT	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.00	0.53	1.87	0.998
Furnitures	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.01	0.63	1.61	0.979
Unsustained work pace	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.14	0.58	2.22	0.711
Enough time to complete the volume of work	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.24	0.79	1.93	0.352
Full attention not required to perform work activities	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	0.69	0.07	6.70	0.745
Autonomy in professional activity	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.17	0.70	1.97	0.548
Good rapports with hierarchy	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.27	0.71	2.28	0.423
Good rapports with other radiographers	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.80	0.49	6.61	0.368
Good rapports with other healthcare workers	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.27	0.57	2.84	0.566
Not feeling anxiety/stress	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.80	1.11	2.91	0.016*
Satisfied with professional activity	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	2.07	0.96	- 4.84	0.051
Gender	Men	1.00			
	Women	1.60	1.01	2.53	0.043*
Age	20-29 yo	1.00			
	30-39 yo	0.67	0.36	1.25	
	40-49 yo	0.65	0.33	1.31	
	50-59 yo	1.66	0.77	3.59	
	60 yo and more	0.51	0.17	1.57	0.566
Diseases or health disorders	No	1.00			
	Yes	1.29	0.79	2.10	0.310
Years of experience	≤ 5 years	1.00			
	6-10 years	1.02	0.52	2.00	
	11-15 years	1.55	0.76	3.19	
	16-20 years	1.15	0.53	2.50	
	> 20 years	1.76	0.96	3.20	0.056

* *Significant results (p≤0.05).*

Table 28 - Associative analysis between WRMSDs symptoms in the shoulders and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.80	1.18 - 2.76	0.006*
Physical force	Never/Sometimes	1.00		
	Often/Always	1.64	0.99 - 2.69	0.051
Static postures	Never/Sometimes	1.00		
	Often/Always	1.10	0.72 - 1.67	0.671
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	0.94	0.61 - 1.44	0.776
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.20	0.78 - 1.83	0.407
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.67	1.06 - 2.62	0.025
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.39	0.86 - 2.23	0.176
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.33	0.81 - 2.19	0.260
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.42	0.80 - 2.51	0.224
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.53	0.90 - 2.60	0.115
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.58	0.85 - 2.93	0.143
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.30	0.83 - 2.03	0.247
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.12	0.59 - 2.12	0.738
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.60	1.04 - 2.44	0.030
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*		
	Totally/Mostly disagree			
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.00	0.62 - 1.62	0.996
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.64	0.94 - 2.87	0.078
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.06	0.63 - 6.73	0.221
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.58	0.74 - 3.40	0.236
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.85	1.18 - 2.89	0.006*
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.43	1.23 - 4.80	0.008*
Gender	Men	1.00		
	Women	1.70	1.09 - 2.64	0.017*
Age	20-29 yo	1.00		
	30-39 yo	1.26	0.71 - 2.25	
	40-49 yo	1.39	0.72 - 2.66	
	50-59 yo	2.28	1.15 - 4.49	
	60 yo and more	2.51	0.78 - 8.08	0.008*
Diseases or health disorders	No	1.00		
	Yes	1.64	1.03 - 2.60	0.035*
Years of experience	≤ 5 years	1.00		
	6-10 years	1.07	0.56 - 2.07	
	11-15 years	1.24	0.64 - 2.42	
	16-20 years	1.50	0.70 - 3.20	
	> 20 years	1.58	0.90 - 2.77	0.072

* *Significant results (p≤0.05).*

Table 29 - Associative analysis between WRMSDs symptoms in the elbows and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.29	0.73 - 2.28	0.374
Physical force	Never/Sometimes	1.00		
	Often/Always	2.11	0.95 - 4.67	0.060
Static postures	Never/Sometimes	1.00		
	Often/Always	0.96	0.55 - 1.69	0.894
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.28	0.71 - 2.29	0.406
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.18	0.66 - 2.10	0.569
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.14	0.64 - 2.03	0.665
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.07	0.58 - 1.99	0.828
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.52	0.82 - 2.83	0.182
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.94	0.99 - 3.81	0.051
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.66	0.85 - 3.25	0.136
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.91	0.94 - 3.88	0.068
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.94	0.52 - 1.70	0.828
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.54	0.58 - 4.10	0.386
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.80	1.02 - 3.18	0.039*
Full attention not required to perform work activities	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.59	0.06 - 5.75	0.643
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.11	0.59 - 2.08	0.754
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.16	0.57 - 2.33	0.683
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.84	0.18 - 3.85	0.818
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.93	0.34 - 2.54	0.892
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.85	1.05 - 3.27	0.030*
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.80	0.87 - 3.72	0.107
Gender	Men	1.00		
	Women	1.43	0.78 - 2.64	0.250
Age	20-29 yo	1.00		
	30-39 yo	1.16	0.46 - 2.92	
	40-49 yo	1.58	0.59 - 4.21	
	50-59 yo	3.32	1.32 - 8.34	
	60 yo and more	3.92	1.04 - 14.79	0.001*
Diseases or health disorders	No	1.00		
	Yes	2.80	1.56 - 5.01	>0.001*
Years of experience	≤ 5 years	1.00		
	6-10 years	0.62	0.18 - 2.10	
	11-15 years	1.61	0.61 - 4.26	
	16-20 years	1.48	0.50 - 4.43	0.001*
	> 20 years	3.11	1.40 - 6.90	

* *Significant results (p≤0.05).*

Table 30 - Associative analysis between WRMSDs symptoms in the wrists/hands and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	0.83	0.51 - 1.34	0.440
Physical force	Never/Sometimes	1.00		
	Often/Always	2.10	1.09 - 4.04	0.023*
Static postures	Never/Sometimes	1.00		
	Often/Always	1.21	0.75 - 1.95	0.437
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	0.91	0.56 - 1.47	0.692
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.03	0.64 - 1.69	0.891
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.19	0.72 - 1.95	0.498
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.14	0.68 - 1.93	0.619
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.52	0.89 - 2.60	0.124
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.51	0.83 - 2.75	0.179
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.17	0.65 - 2.11	0.595
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.23	0.64 - 2.37	0.531
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.18	0.72 - 1.95	0.507
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.99	0.48 - 2.06	0.979
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.40	0.87 - 2.26	0.167
Full attention not required to perform work activities	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.02	0.10 - 9.95	0.987
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.06	0.62 - 1.83	0.823
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.11	0.61 - 2.03	0.730
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.48	0.11 - 2.21	0.338
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.52	0.19 - 1.40	0.188
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.14	0.70 - 1.86	0.593
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.20	0.61 - 2.35	0.595
Gender	Men	1.00		
	Women	1.41	0.84 - 2.36	0.188
Age	20-29 yo	1.00		
	30-39 yo	1.27	0.61 - 2.63	
	40-49 yo	1.53	0.69 - 3.38	
	50-59 yo	2.70	1.25 - 5.84	
	60 yo and more	2.05	0.60 - 6.94	0.007*
Diseases or health disorders	No	1.00		
	Yes	2.18	1.32 - 3.60	0.002*
Years of experience	≤ 5 years	1.00		
	6-10 years	1.31	0.58 - 2.95	
	11-15 years	1.51	0.67 - 3.38	
	16-20 years	1.72	0.71 - 4.14	
	> 20 years	2.17	1.11 - 4.25	0.016*

* *Significant results (p≤0.05).*

Table 31 - Associative analysis between WRMSDs symptoms in the hips/thighs and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.69	0.92 - 3.10	0.085
Physical force	Never/Sometimes	1.00		
	Often/Always	1.59	0.74 - 3.41	0.233
Static postures	Never/Sometimes	1.00		
	Often/Always	1.26	0.70 - 2.27	0.436
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.30	0.71 - 2.38	0.393
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.95	1.03 - 3.71	0.037
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.27	0.70 - 2.32	0.428
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.90	0.47 - 1.74	0.758
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.80	0.39 - 1.62	0.528
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.57	0.23 - 1.40	0.212
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.64	0.28 - 1.44	0.275
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.85	0.36 - 1.99	0.704
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.10	0.60 - 2.01	0.767
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.11	0.44 - 2.77	0.826
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.36	0.76 - 2.43	0.303
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*		
	Totally/Mostly disagree			
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.71	0.35 - 1.45	0.349
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.22	0.07 - 0.74	0.007*
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.95	0.21 - 4.40	0.952
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.36	0.08 - 1.56	0.155
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.10	1.16 - 3.80	0.012*
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.48	0.16 - 1.41	0.172
Gender	Men	1.00		
	Women	1.36	0.72 - 2.55	0.339
Age	20-29 yo	1.00		
	30-39 yo	0.56	0.22 - 1.39	
	40-49 yo	1.47	0.62 - 3.52	
	50-59 yo	1.45	0.61 - 3.46	
	60 yo and more	2.00	0.54 - 7.44	0.054
Diseases or health disorders	No	1.00		
	Yes	1.67	0.92 - 3.04	0.091
Years of experience	≤ 5 years	1.00		
	6-10 years	0.29	0.08 - 1.06	
	11-15 years	0.41	0.13 - 1.31	
	16-20 years	0.75	0.25 - 2.24	
	> 20 years	1.69	0.83 - 3.43	0.030*

* *Significant results (p≤0.05).*

Table 32 - Associative analysis between WRMSDs symptoms in the knees and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	0.89	0.54 - 1.45	0.631
Physical force	Never/Sometimes	1.00		
	Often/Always	1.38	0.75 - 2.55	0.299
Static postures	Never/Sometimes	1.00		
	Often/Always	1.06	0.65 - 1.73	0.827
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.25	0.75 - 2.06	0.392
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	0.83	0.51 - 1.36	0.465
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.83	0.49 - 1.41	0.499
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.04	0.60 - 1.79	0.891
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.07	0.61 - 1.89	0.811
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.73	0.37 - 1.45	0.368
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.13	0.62 - 2.07	0.691
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.20	0.62 - 2.35	0.586
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.73	0.43 - 1.25	0.246
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.89	0.43 - 1.86	0.763
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.24	0.76 - 2.01	0.396
Full attention not required to perform work activities	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.93	0.10 - 9.09	0.950
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.20	0.70 - 2.08	0.506
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.20	0.66 - 2.13	0.056
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.34	0.41 - 4.39	0.631
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.07	0.46 - 2.48	0.875
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.55	0.94 - 2.56	0.080
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.68	0.87 - 3.24	0.118
Gender	Men	1.00		
	Women	1.42	0.84 - 2.42	0.189
Age	20-29 yo	1.00		
	30-39 yo	1.02	0.51 - 2.08	
	40-49 yo	1.20	0.55 - 2.61	
	50-59 yo	1.37	0.64 - 2.94	
	60 yo and more	1.27	0.36 - 4.51	0.361
Diseases or health disorders	No	1.00		
	Yes	1.30	0.78 - 2.18	0.319
Years of experience	≤ 5 years	1.00		
	6-10 years	0.52	0.21 - 1.28	
	11-15 years	1.31	0.62 - 2.78	
	16-20 years	1.24	0.53 - 2.89	
	> 20 years	1.10	0.58 - 2.10	0.385

* *Significant results (p≤0.05).*

Table 33 - Associative analysis between WRMSDs symptoms in the ankles/feet and risk factors (last 12 months).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.21	0.73 - 2.01	0.465
Physical force	Never/Sometimes	1.00		
	Often/Always	1.64	0.85 - 3.17	0.135
Static postures	Never/Sometimes	1.00		
	Often/Always	1.27	0.76 - 2.11	0.360
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.28	0.76 - 2.15	0.355
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.35	0.80 - 2.28	0.263
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.49	0.88 - 2.50	0.134
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.21	0.70 - 2.11	0.487
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.04	0.58 - 1.88	0.885
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.91	0.46 - 1.78	0.778
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.26	0.70 - 2.28	0.439
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.19	1.15 - 4.17	0.015*
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.33	0.79 - 2.24	0.287
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.94	1.01 - 8.57	0.038*
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.76	1.06 - 2.94	0.028*
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*		
	Totally/Mostly disagree			
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.85	0.47 - 1.53	0.581
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.41	0.76 - 2.60	0.271
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.60	0.13 - 2.73	0.500
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.81	0.32 - 2.05	0.654
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.86	1.11 - 3.10	0.016*
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.53	0.77 - 3.01	0.221
Gender	Men	1.00		
	Women	1.12	0.66 - 1.91	0.670
Age	20-29 yo	1.00		
	30-39 yo	1.11	0.50 - 2.42	
	40-49 yo	1.71	0.74 - 3.91	
	50-59 yo	2.54	1.13 - 5.70	
	60 yo and more	1.81	0.49 - 6.63	0.011*
Diseases or health disorders	No	1.00		
	Yes	1.66	0.98 - 2.80	0.057
Years of experience	≤ 5 years	1.00		
	6-10 years	1.41	0.62 - 3.21	
	11-15 years	0.81	0.32 - 2.05	
	16-20 years	1.03	0.39 - 2.76	
	> 20 years	2.15	1.09 - 4.26	0.034*

* *Significant results (p≤0.05).*

Table 34 - Associative analysis between WRMSDs symptoms in the neck and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	2.01	1.21 - 3.34	0.006*
Physical force	Never/Sometimes	1.00		
	Often/Always	2.03	1.09 - 3.77	0.023*
Static postures	Never/Sometimes	1.00		
	Often/Always	1.02	0.62 - 1.66	0.946
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.15	0.70 - 1.91	0.577
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.84	1.10 - 3.05	0.018*
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.33	0.81 - 2.21	0.260
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.79	0.47 - 1.35	0.395
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.88	0.51 - 1.53	0.647
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.68	0.88 - 3.18	0.111
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.85	0.47 - 1.53	0.587
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.83	0.43 - 1.60	0.579
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.94	0.57 - 1.56	0.824
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.27	0.60 - 2.70	0.537
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.64	1.01 - 2.68	0.048*
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*		
	Totally/Mostly disagree			
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.03	0.60 - 1.77	0.906
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.19	0.65 - 2.19	0.578
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.17	0.35 - 3.95	0.798
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.67	0.27 - 1.63	0.373
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.00	1.20 - 3.34	0.007*
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.48	0.75 - 2.91	0.256
Gender	Men	1.00		
	Women	2.64	1.51 - 4.61	>0.001*
Age	20-29 yo	1.00		
	30-39 yo	1.27	0.46 - 0.497	
	40-49 yo	1.71	1.81 - 0.178	
	50-59 yo	1.60	1.52 - 0.218	
	60 yo and more	2.43	1.73 - 0.188	0.095
Diseases or health disorders	No	1.00		
	Yes	1.80	1.07 - 3.02	0.025*
Years of experience	≤ 5 years	1.00		
	6-10 years	0.90	0.42 - 1.94	
	11-15 years	1.07	0.49 - 2.35	
	16-20 years	1.50	0.61 - 3.70	
	> 20 years	1.37	0.71 - 2.64	0.203

* *Significant results (p≤0.05).*

Table 35 - Associative analysis between WRMSDs symptoms in the upper back and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.49	0.78 - 2.84	0.219
Physical force	Never/Sometimes	1.00		
	Often/Always	0.91	0.41 - 2.00	0.812
Static postures	Never/Sometimes	1.00		
	Often/Always	1.28	0.69 - 2.40	0.430
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.44	0.76 - 2.72	0.261
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.52	0.80 - 2.86	0.195
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.13	1.09 - 4.15	0.023*
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.65	0.33 - 1.27	0.202
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.16	0.57 - 2.35	0.686
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.37	0.59 - 3.18	0.457
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.87	0.41 - 1.81	0.702
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.70	0.73 - 3.92	0.213
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.14	1.08 - 4.25	0.026*
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.14	0.76 - 6.09	0.142
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.25	0.67 - 2.33	0.481
Full attention not required to perform work activities	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.99	0.06 - 16.20	0.993
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.92	0.95 - 3.90	0.066
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.45	0.69 - 3.04	0.329
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.81	0.24 - 2.79	0.739
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.83	0.21 - 3.24	0.792
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.93	1.02 - 3.67	0.041*
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.02	0.88 - 4.62	0.091
Gender	Men	1.00		
	Women	1.04	0.53 - 2.02	0.908
Age	20-29 yo	1.00		
	30-39 yo	1.26	0.54 - 2.97	
	40-49 yo	2.44	0.90 - 6.66	
	50-59 yo	1.38	0.52 - 3.64	
	60 yo and more	5.87	0.53 - 64.38	0.118
Diseases or health disorders	No	1.00		
	Yes	1.93	0.97 - 3.83	0.056
Years of experience	≤ 5 years	1.00		
	6-10 years	0.90	0.35 - 2.32	
	11-15 years	0.70	0.24 - 2.04	
	16-20 years	0.76	0.26 - 2.25	
	> 20 years	1.54	0.67 - 3.51	0.358

* *Significant results (p≤0.05).*

Table 36 - Associative analysis between WRMSDs symptoms in the lower back and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.66	0.98 - 2.81	0.059
Physical force	Never/Sometimes	1.00		
	Often/Always	1.79	0.92 - 3.49	0.084
Static postures	Never/Sometimes	1.00		
	Often/Always	1.07	0.64 - 1.79	0.786
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.52	0.90 - 2.56	0.113
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	0.90	0.54 - 1.51	0.684
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.68	0.98 - 2.86	0.055
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.32	0.76 - 2.31	0.323
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.48	0.82 - 2.69	0.192
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.72	0.89 - 3.33	0.101
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.32	0.69 - 2.52	0.395
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.56	0.74 - 3.29	0.233
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.27	0.74 - 2.17	0.390
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.14	0.52 - 2.51	0.745
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.12	0.67 - 1.86	0.661
Full attention not required to perform work activities	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.56	0.05 - 6.27	0.631
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.20	0.68 - 2.14	0.531
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.20	0.63 - 2.26	0.583
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.06	0.31 - 3.59	0.923
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.21	0.51 - 2.88	0.672
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.38	1.39 - 4.08	0.001*
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.94	0.94 - 4.02	0.069
Gender	Men	1.00		
	Women	1.96	1.12 - 3.41	0.016*
Age	20-29 yo	1.00		
	30-39 yo	0.67	0.33 - 1.36	
	40-49 yo	0.91	0.41 - 2.03	
	50-59 yo	1.36	0.64 - 2.90	
	60 yo and more	1.67	0.37 - 7.48	0.171
Diseases or health disorders	No	1.00		
	Yes	2.39	1.35 - 4.25	0.002*
Years of experience	≤ 5 years	1.00		
	6-10 years	0.70	0.30 - 1.62	
	11-15 years	0.71	0.32 - 1.61	
	16-20 years	0.64	0.25 - 1.64	
	> 20 years	1.51	0.76 - 3.01	0.173

* *Significant results (p≤0.05).*

Table 37 - Associative analysis between WRMSDs symptoms in the shoulders and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI		P-value global test
Awkward postures	Never/Sometimes	1.00	.	.	
	Often/Always	2.46	1.31	4.61	0.004*
Physical force	Never/Sometimes	1.00	.	.	
	Often/Always	1.51	0.71	3.21	0.286
Static postures	Never/Sometimes	1.00	.	.	
	Often/Always	1.44	0.81	2.57	0.217
Repetitive movements	Never/Sometimes	1.00	.	.	
	Often/Always	2.20	1.18	4.07	0.010*
Long/numerous reaches	Never/Sometimes	1.00	.	.	
	Often/Always	1.46	0.80	2.65	0.214
Physical environment	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.27	0.71	2.28	0.426
Service layout	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	0.84	0.45	1.56	0.574
Workspace	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	0.97	0.51	1.86	0.927
Radiological equipment	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.84	0.90	3.77	0.089
Radiological accessories	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.01	0.51	1.99	0.987
IT	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.28	0.60	2.70	0.520
Furnitures	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	0.83	0.45	1.50	0.531
Unsustained work pace	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	3.41	1.10	10.63	0.024*
Enough time to complete the volume of work	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	1.61	0.90	2.87	0.105
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*			
	Totally/Mostly disagree				
Autonomy in professional activity	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	0.72	0.37	1.41	0.338
Good rapports with hierarchy	Totally/Mostly agree	1.00		.	
	Totally/Mostly disagree	0.67	0.33	1.37	0.270
Good rapports with other radiographers	Totally/Mostly agree	1.00		.	
	Totally/Mostly disagree	2.42	0.65	8.94	0.172
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		.	
	Totally/Mostly disagree	0.81	0.31	2.11	0.659
Not feeling anxiety/stress	Totally/Mostly agree	1.00		.	
	Totally/Mostly disagree	2.11	1.16	3.82	0.012*
Satisfied with professional activity	Totally/Mostly agree	1.00		.	
	Totally/Mostly disagree	1.73	0.83	3.61	0.136
Gender	Men	1.00			
	Women	2.19	1.11	4.29	0.020*
Age	20-29 yo	1.00			
	30-39 yo	1.25	0.52	3.03	
	40-49 yo	1.42	0.54	3.74	
	50-59 yo	1.92	0.76	4.85	
	60 yo and more	1.89	0.46	7.76	0.124
Diseases or health disorders	No	1.00			
	Yes	2.56	1.39	4.73	0.002*
Years of experience	≤ 5 years	1.00			
	6-10 years	1.24	0.47	1.94	
	11-15 years	1.35	0.52	2.35	
	16-20 years	1.28	0.45	3.70	
	> 20 years	1.79	0.81	2.64	0.147

* *Significant results (p≤0.05).*

Table 38 - Associative analysis between WRMSDs symptoms in the elbows and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI		P-value global test
Awkward postures	Never/Sometimes	1.00			
	Often/Always	1.12	0.39	3.19	0.838
Physical force	Never/Sometimes	1.00			
	Often/Always	1.60	0.34	7.56	0.548
Static postures	Never/Sometimes	1.00			
	Often/Always	1.52	0.53	4.36	0.429
Repetitive movements	Never/Sometimes	1.00			
	Often/Always	3.44	1.03	11.45	0.032*
Long/numerous reaches	Never/Sometimes	1.00			
	Often/Always	1.14	0.39	3.31	0.814
Physical environment	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.58	0.54	4.63	0.405
Service layout	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.36	0.43	4.27	0.595
Workspace	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	0.61	0.19	1.91	0.387
Radiological equipment	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	0.45	0.13	1.61	0.209
Radiological accessories	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	0.56	0.16	1.98	0.363
IT	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	2.19	0.60	7.97	0.223
Furnitures	Totally/Mostly adequate	1.00			
	Totally/Mostly inadequate	1.36	0.45	4.11	0.587
Unsustained work pace	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.34	0.20	8.83	0.761
Enough time to complete the volume of work	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.27	0.45	3.63	0.651
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*			
	Totally/Mostly disagree				
Autonomy in professional activity	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.15	0.36	3.67	0.813
Good rapports with hierarchy	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.19	0.33	4.30	0.790
Good rapports with other radiographers	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.81	0.19	- 23.13	0.656
Good rapports with other healthcare workers	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	1.81	0.27	12.02	0.532
Not feeling anxiety/stress	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	0.94	0.33	2.63	0.902
Satisfied with professional activity	Totally/Mostly agree	1.00			
	Totally/Mostly disagree	0.75	0.20	2.72	0.655
Gender	Men	1.00			
	Women	1.02	0.33	3.19	0.969
Age	20-29 yo	1.00			
	30-39 yo	0.56	0.09	3.44	
	40-49 yo	0.57	0.08	3.90	
	50-59 yo	1.86	0.34	10.27	
	60 yo and more	0.67	0.06	7.11	0.392
Diseases or health disorders	No	1.00			
	Yes	5.25	1.55	17.78	0.003*
Years of experience	≤ 5 years	1.00			
	6-10 years	1.00	0.09	11.10	
	11-15 years	0.50	0.07	3.47	
	16-20 years	0.50	0.06	4.51	
	> 20 years	1.14	0.27	4.88	0.729

* *Significant results (p≤0.05).*

Table 39 - Associative analysis between WRMSDs symptoms in the wrists/hands and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.80	0.77 - 4.20	0.170
Physical force	Never/Sometimes	1.00		
	Often/Always	5.50	1.08 - 28.02	0.021*
Static postures	Never/Sometimes	1.00		
	Often/Always	0.84	0.36 - 1.94	0.680
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.27	0.54 - 2.98	0.576
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	1.30	0.55 - 3.06	0.548
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.74	0.73 - 4.16	0.209
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.78	0.31 - 1.95	0.593
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.97	0.39 - 2.40	0.940
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.28	0.81 - 6.44	0.110
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.79	0.28 - 2.24	0.664
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.13	0.68 - 6.71	0.187
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.51	0.63 - 3.59	0.353
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.98	0.27 - 3.51	0.978
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.66	0.71 - 3.86	0.236
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*		
	Totally/Mostly disagree			
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.65	0.64 - 4.25	0.298
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.32	0.47 - 3.75	0.598
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.20	0.07 - 20.12	0.899
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.81	0.13 - 5.14	0.820
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.85	0.78 - 4.37	0.156
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.90	0.28 - 2.86	0.858
Gender	Men	1.00		
	Women	2.53	0.94 - 6.78	0.056
Age	20-29 yo	1.00	. .	
	30-39 yo	0.47	0.12 - 1.83	
	40-49 yo	0.60	0.14 - 2.54	
	50-59 yo	0.60	0.16 - 2.27	
	60 yo and more	0.50	0.06 - 4.34	0.663
Diseases or health disorders	No	1.00		
	Yes	1.71	0.73 - 4.01	0.209
Years of experience	≤ 5 years	1.00		
	6-10 years	0.40	0.08 - 1.92	
	11-15 years	1.60	0.36 - 7.05	
	16-20 years	0.20	0.03 - 1.40	
	> 20 years	0.80	0.25 - 2.56	0.766

* *Significant results (p≤0.05).*

Table 40 - Associative analysis between WRMSDs symptoms in the hips/thighs and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.35	0.43 - 4.22	0.604
Physical force	Never/Sometimes	1.00		
	Often/Always	0.13	0.01 - 1.14	0.062
Static postures	Never/Sometimes	1.00		
	Often/Always	1.98	0.64 - 6.12	0.224
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.35	0.43 - 4.22	0.604
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	0.58	0.16 - 2.07	0.398
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.75	0.24 - 2.31	0.619
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.99	0.28 - 3.41	0.982
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.86	0.22 - 3.32	0.831
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	4.78	0.48 - 47.60	0.140
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.59	0.12 - 2.85	0.507
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.02	0.35 - 11.79	0.426
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.44	0.45 - 4.61	0.533
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.64	0.11 - 3.93	0.630
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.53	0.17 - 1.62	0.258
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*		
	Totally/Mostly disagree			
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.34	0.08 - 1.40	0.117
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.72	0.04 - 12.60	0.824
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.70	0.04 - 12.18	0.806
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.72	0.04 - 12.61	0.824
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.11	0.37 - 3.32	0.847
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.33	0.22 - 24.93	0.470
Gender	Men	1.00		
	Women	1.07	0.33 - 3.52	0.912
Age	20-29 yo	1.00		
	30-39 yo	4.00	0.55 - 29.27	
	40-49 yo	4.80	0.73 - 31.68	
	50-59 yo	6.67	0.90 - 49.33	
	60 yo and more	2.67	0.22 - 32.73	0.091
Diseases or health disorders	No	1.00		
	Yes	2.14	0.67 - 6.86	0.188
Years of experience	≤ 5 years	1.00		
	6-10 years	3.00	0.19 - 46.67	
	11-15 years	1.50	0.15 - 14.72	
	16-20 years	*Not enough observations*		
	> 20 years	2.18	0.58 - 8.21	0.190

** Significant results (p≤0.05).*

Table 41 - Associative analysis between WRMSDs symptoms in the knees and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI	P-value global test
Awkward postures	Never/Sometimes	1.00		
	Often/Always	1.35	0.43 - 4.22	0.604
Physical force	Never/Sometimes	1.00		
	Often/Always	0.93	0.25 - 3.24	1.000
Static postures	Never/Sometimes	1.00		
	Often/Always	1.98	0.64 - 6.12	0.224
Repetitive movements	Never/Sometimes	1.00		
	Often/Always	1.35	0.43 - 4.22	0.604
Long/numerous reaches	Never/Sometimes	1.00		
	Often/Always	0.58	0.16 - 2.07	0.398
Physical environment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.75	0.24 - 2.31	0.619
Service layout	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.99	0.28 - 3.41	0.982
Workspace	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.86	0.22 - 3.32	0.831
Radiological equipment	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	4.78	0.48 - 47.60	0.140
Radiological accessories	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	0.59	0.12 - 2.85	0.507
IT	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	2.02	0.35 - 11.79	0.426
Furnitures	Totally/Mostly adequate	1.00		
	Totally/Mostly inadequate	1.44	0.45 - 4.61	0.533
Unsustained work pace	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.64	0.11 - 3.93	0.630
Enough time to complete the volume of work	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.53	0.17 - 1.62	0.258
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*		
	Totally/Mostly disagree			
Autonomy in professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.34	0.08 - 1.40	0.117
Good rapports with hierarchy	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.18	0.39 - 3.76	0.804
Good rapports with other radiographers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.70	0.04 - 12.18	0.806
Good rapports with other healthcare workers	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	0.72	0.04 - 12.61	0.824
Not feeling anxiety/stress	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	1.11	0.37 - 3.32	0.847
Satisfied with professional activity	Totally/Mostly agree	1.00		
	Totally/Mostly disagree	2.33	0.22 - 24.93	0.470
Gender	Men	1.00		
	Women	1.07	0.33 - 3.52	0.912
Age	20-29 yo	1.00		
	30-39 yo	4.00	0.55 - 29.27	
	40-49 yo	4.80	0.73 - 31.68	
	50-59 yo	6.67	0.90 - 49.33	
	60 yo and more	2.67	0.22 - 32.73	0.091
Diseases or health disorders	No	1.00		
	Yes	2.14	0.67 - 6.86	0.188
Years of experience	≤ 5 years	1.00		
	6-10 years	3.00	0.19 46.67	
	11-15 years	1.50	0.15 - 14.72	
	16-20 years	*Not enough observations*		
	> 20 years	2.18	0.58 - 8.21	0.206

* *Significant results (p≤0.05).*

Table 42 - Associative analysis between WRMSDs symptoms in the ankles/feet and risk factors (last 7 days).

Risk factors	Categories	OR	95% CI		P-value global test
Awkward postures	Never/Sometimes	1.00	.	.	
	Often/Always	0.71	0.28	1.81	0.476
Physical force	Never/Sometimes	1.00	.	.	
	Often/Always	6.52	1.49	28.58	0.004*
Static postures	Never/Sometimes	1.00	.	.	
	Often/Always	0.55	0.21	1.42	0.208
Repetitive movements	Never/Sometimes	1.00	.	.	
	Often/Always	0.89	0.35	2.31	0.816
Long/numerous reaches	Never/Sometimes	1.00	.	.	
	Often/Always	1.20	0.46	3.11	0.708
Physical environment	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.01	0.40	2.57	0.980
Service layout	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	3.80	1.18	12.27	0.016*
Workspace	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.71	0.56	5.18	0.339
Radiological equipment	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	4.85	0.93	47.68	0.061
Radiological accessories	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.10	0.39	3.14	0.857
IT	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.08	0.36	3.20	0.893
Furnitures	Totally/Mostly adequate	1.00	.	.	
	Totally/Mostly inadequate	1.07	0.42	2.73	0.885
Unsustained work pace	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	0.48	0.05	4.92	0.525
Enough time to complete the volume of work	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	1.93	0.76	4.92	0.159
Full attention not required to perform work activities	Totally/Mostly agree	*Not enough observations*			
	Totally/Mostly disagree				
Autonomy in professional activity	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	1.12	0.38	3.32	0.835
Good rapports with hierarchy	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	0.83	0.29	2.43	0.738
Good rapports with other radiographers	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	0.70	0.04	11.93	0.807
Good rapports with other healthcare workers	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	0.33	0.05	1.96	0.197
Not feeling anxiety/stress	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	1.53	0.61	3.84	0.360
Satisfied with professional activity	Totally/Mostly agree	1.00	.	.	
	Totally/Mostly disagree	0.64	0.20	2.07	0.454
Gender	Men	1.00	.	2.83	
	Women	1.08	0.41	.	0.872
Age	20-29 yo	1.00	.	3.52	
	30-39 yo	0.82	0.19	11.91	
	40-49 yo	2.40	0.48	8.05	
	50-59 yo	1.88	0.44	10.35	
	60 yo and more	1.00	0.10	.	0.277.
Diseases or health disorders	No	1.00	.	8.37	
	Yes	3.00	1.07	.	0.028*
Years of experience	≤ 5 years	1.00	.	3.82	
	6-10 years	0.86	0.19	9.93	
	11-15 years	1.67	0.28	8.34	
	16-20 years	1.33	0.21	7.27	
	> 20 years	2.09	0.60	3.82	0.149

* *Significant results (p≤0.05).*

APPENDIX VIII – OBSERVATIONS' RESULTS

Table 43 - Time taken to perform the selected tasks before and after image acquisition (in seconds) and total time taken (in min:sec), by observation.

Tasks	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8
Patient handling	50	44	33	47	29	37	47	32
Detector positioning								
Control detector position								
X-ray tube manipulation								
Image acquisition								
X-ray tube removal	19	26	15	25	20	29	26	17
Patient handling								
Detector removal								
Total time	1:08	1:09	0:48	1:11	0:49	1:06	1:14	0:49

Obs. = Observation

Table 44 - The most demanding postures adopted by the "helping radiographer" during the observed situations of chest X-rays in bedridden patients.

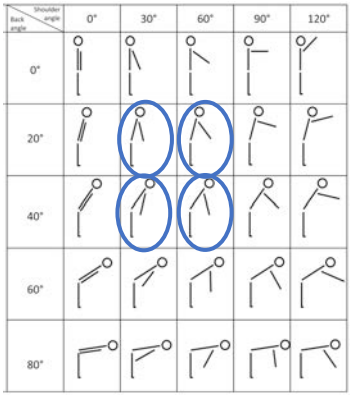
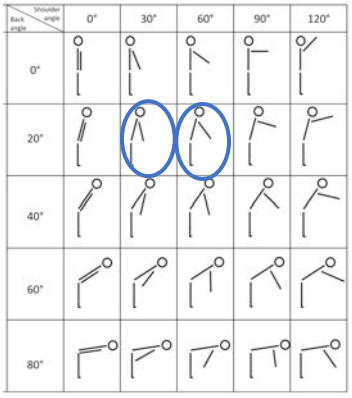
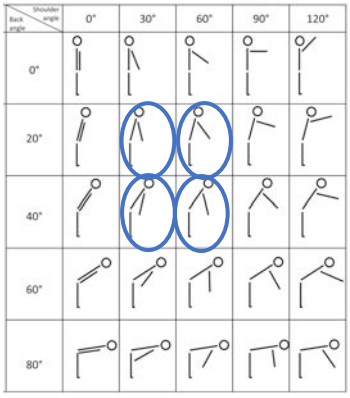
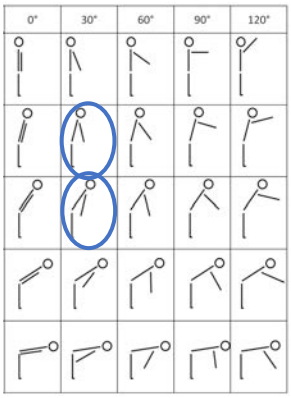
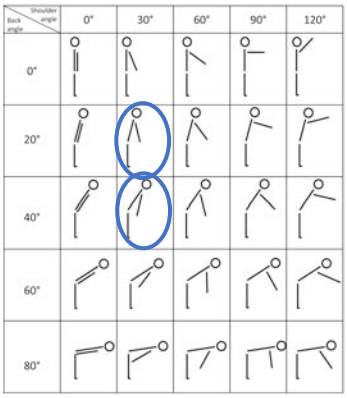
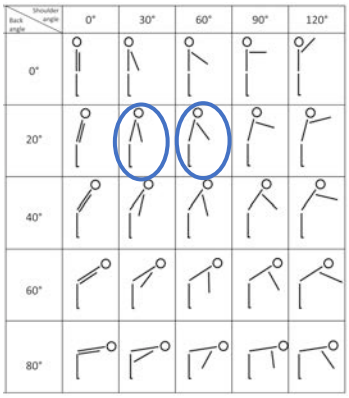
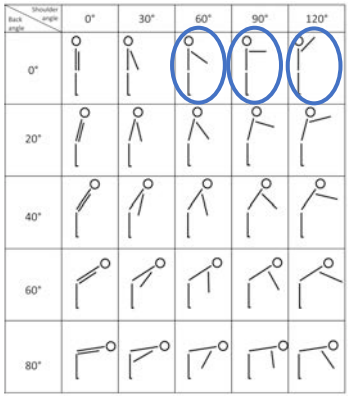
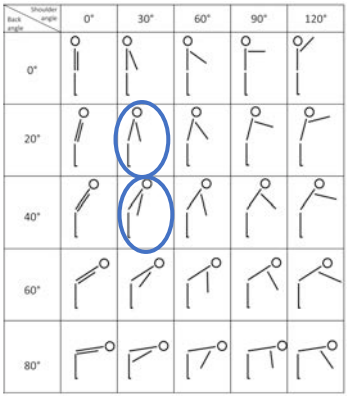
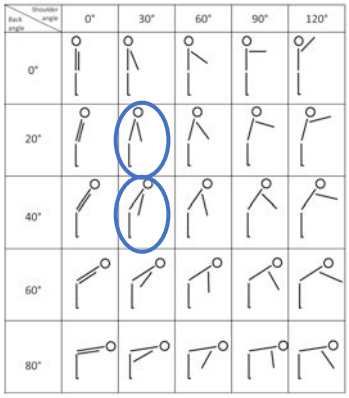
1. Patient handling to position the detector under the patient's back	3. Control of detector position	5. Patient handling to remove the detector from under the patient's back
		

Table 45 - The most demanding postures adopted by the "performing radiographer" during the observed situations of chest X-rays in bedridden patients.

1. Patient handling to position the detector under the patient's back	2. Positioning the detector under the patient's back	3. Control of detector position
		
4. X-ray tube manipulation	**5. Patient handling to remove the detector from under the patient's back**	**6. Detector removal**
		

APPENDIX IX - SIMULATIONS' RESULTS

Figure 13 - Postures' illustrations of the taller radiographer (performer) and shorter radiographer (helper) performing chest X-ray in scenario 1: a & b) preparation to position the detector under the patient's back; c & d) patient handling to position the detector under the patient's back; e) control of detector position; f) X-ray tube positioning; g & h) preparation to remove the detector from under the patient's back; i & j) patient handling to remove the detector from under the patient's back.

Table 46 - Angles measured on the taller radiographer (performer) & shorter radiographer (helper) in scenario 1.

		Trunk forward/ backward bending		Upper arm flexion/extension		Neck/Head upward/downward bending	
	Rad	Measured angle	Obs.	Measured angle	Obs.	Measured angle	Obs.
Preparation to position the detector under the patient's back	Rad 1	48°	Condit. accept.	20°	Condit. accept.	11°	Accept.
	Rad 3	42°	Condit. accept.	38°	Condit. accept.	-17°	Not accept.
Patient handling to position the detector under the patient's back	Rad 1	37°	Condit. accept.	0°	Accept.	10°	Accept.
	Rad 3	20°	Accept.	31°	Condit. accept.	NM	-
Control of detector position	Rad 1	44°	Condit. accept.	40°	Condit. accept.	0°	Accept.
X-ray tube manipulation	Rad 1	0°	Accept.	52°	Condit. accept.	22°	Accept.
Preparation to remove the detector from under the patient's back	Rad 1	48°	Condit. accept.	28°	Condit. accept.	0°	Accept.
	Rad 3	50°	Condit. accept.	36°	Condit. accept.	-24°	Not accept.
Patient handling to remove the detector from under the patient's back	Rad 1	30°	Accept.	0°	Accept.	16°	Accept.
	Rad 3	31°	Condit. accept.	28°	Condit. accept.	NM°	-

NM = Not measurable; Accept. = Acceptable; Condit. accept. = Conditionally acceptable; Not accept. = Not acceptable.

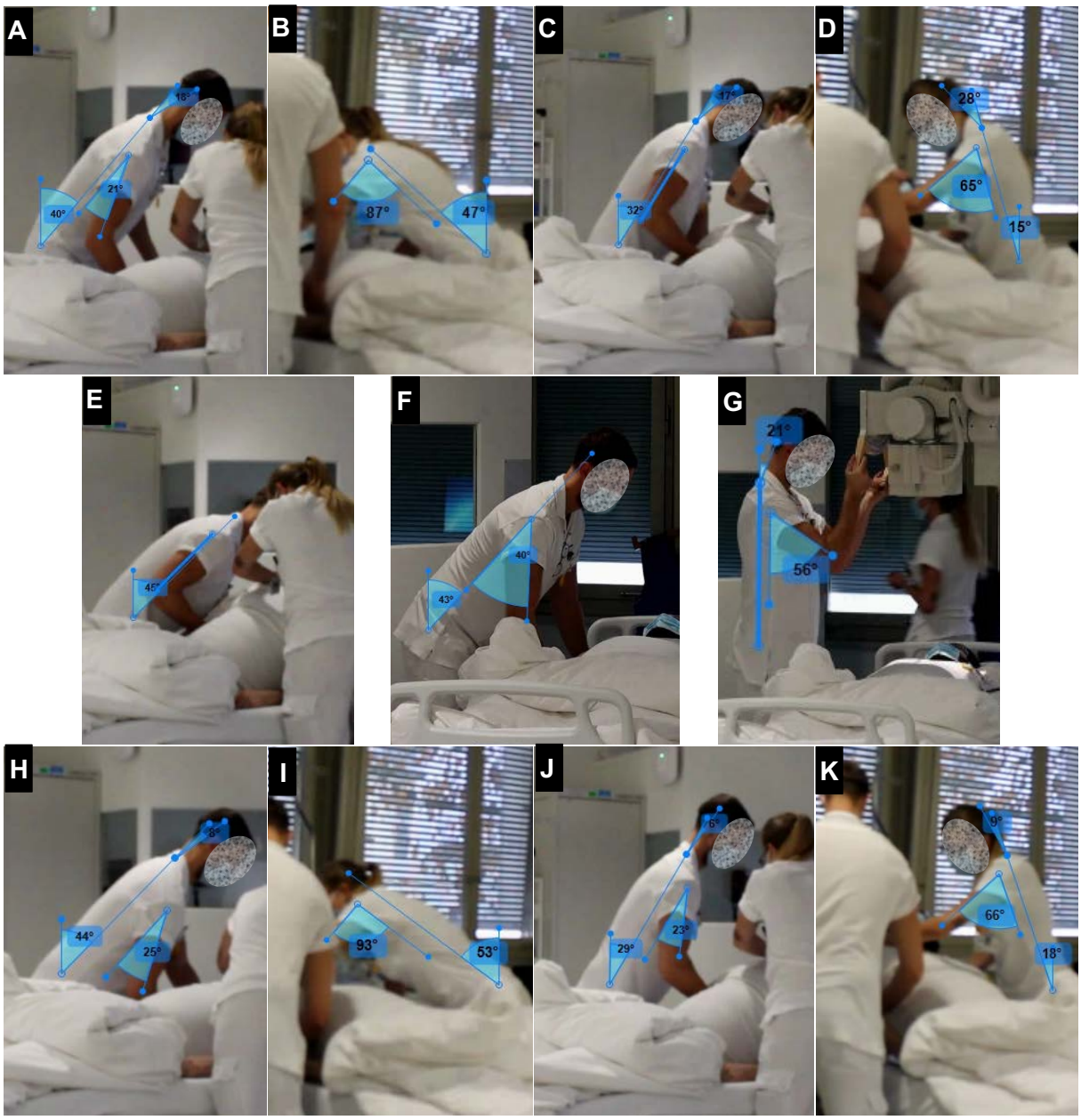


Figure 14 - Postures' illustrations of the taller radiographer (performer) and medium radiographer (helper) performing chest X-ray in scenario 2: a & b) preparation to position the detector under the patient's back; c & d) the patient handling to position the detector under the patient's back; e) positioning the detector under the patient's back; f) control of detector position; g) X-ray tube manipulation; h & i) preparation to remove the detector from under the patient's back; j & k) patient handling to remove the detector from under the patient's back.

Table 47 - Angles measured on the taller radiographer (performer)& medium radiographer (helper) in scenario 2.

		Trunk forward/ backward bending		Upper arm flexion/extension		Neck/Head upward/downward bending	
Activities	**Rad**	Measured angle	Obs.	Measured angle	Obs.	Measured angle	Obs.
Preparation to position the detector under the patient's back	Rad 1	40°	Condit. accept.	21°	Condit. accept.	18°	Accept.
	Rad 2	47°	Condit. accept.	87°	Not accept.	N/M	-
Patient handling to position the detector under the patient's back	Rad 1	32°	Condit. accept.	0°	Accept.	17°	Accept.
	Rad 2	15°	Accept.	65°	Not accept.	38°	Accept.
Positioning the detector under the patient	Rad 1	45°	Condit. accept.	0°	Accept.	N/M	-
Control of detector position	Rad 1	43°	Condit. accept.	40°	Condit. accept.	0°	Accept.
X-ray tube manipulation	Rad 1	0°	Accept.	56°	Condit. accept.	21°	Accept.
Preparation to remove the detector from under the patient's back	Rad 1	44°	Condit. accept.	25°	Condit. accept.	8°	Accept.
	Rad 2	53°	Condit. accept.	93°	Not accept.	N/M	-
Patient handling to remove the detector from under the patient's back	Rad 1	29°	Condit. accept.	23°	Condit. accept.	6°	Accept.
	Rad 2	18°	Accept.	66°	Not accept.	9°	Accept.

N/M = not measurable; Accept. = Acceptable; Condit. accept. = Conditionally acceptable; Not accept. = Not acceptable.

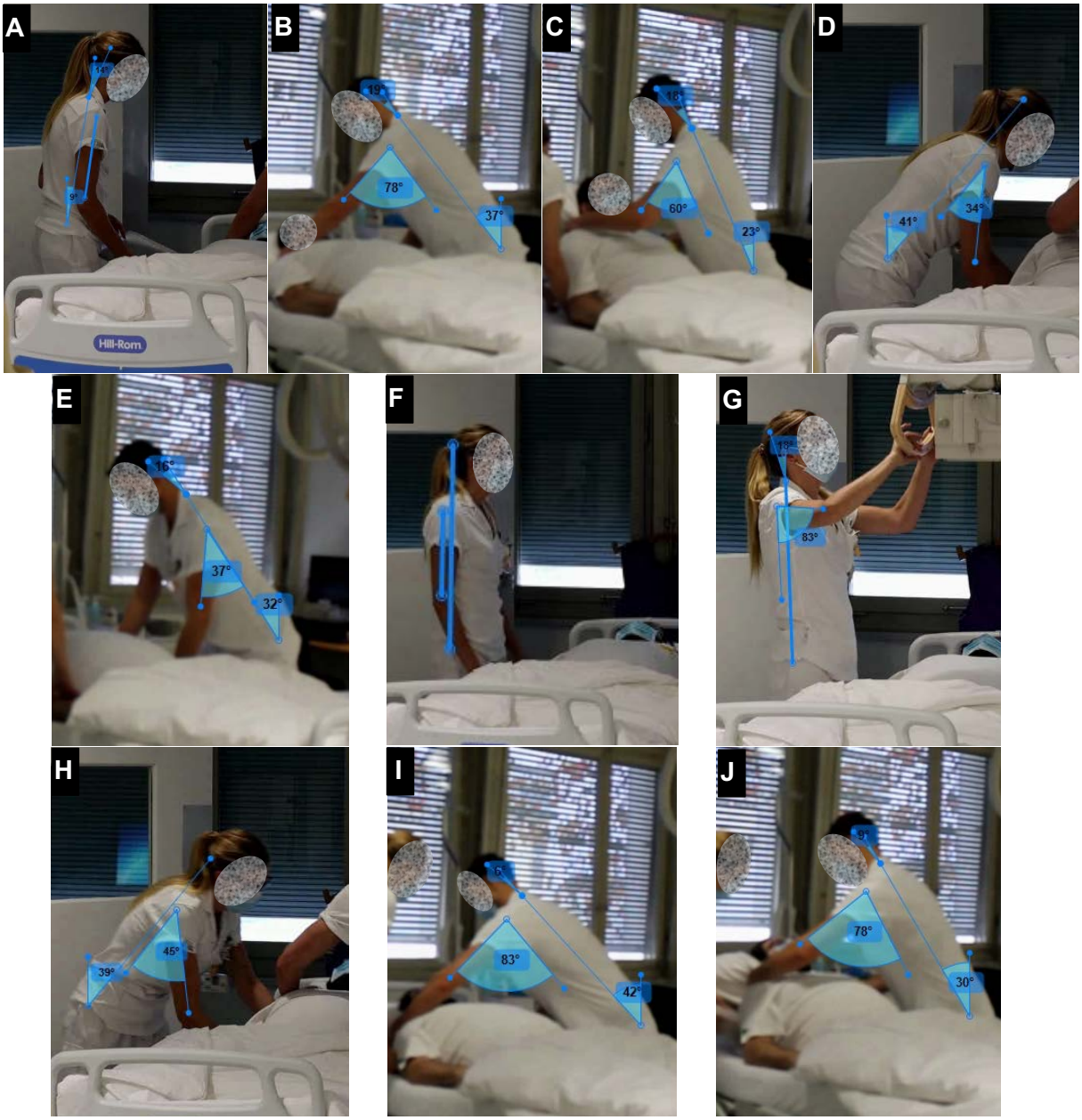


Figure 15 - Postures' illustrations of the medium radiographer (performer) and taller radiographer (helper) in scenario 3: a & b) preparation to position the detector under the patient's back; c) patient handling to position the detector under the patient's back; d) positioning of the detector under the patient's back; e) control of detector position; f) waiting for the X-ray tube; g) X-ray tube manipulation; h & i) the preparation to remove the detector from under the patient's back; j) patient handling to remove the detector from under the patient's back.

Table 48 - Angles measured on the medium radiographer (performer) & taller radiographer (helper) in scenario 3.

Activities	Rad	Trunk forward/ backward bending		Upper arm flexion/extension		Neck/Head upward/downward bending	
		Measured angle	Obs.	Measured angle	Obs.	Measured angle	Obs.
Preparation to position the detector under the patient's back	Rad 2	9°	Accept.	0°	Accept.	14°	Accept.
	Rad 1	37°	Condit. accept.	78°	Not accept.	19°	Accept.
Patient handling to position the detector under the patient's back	Rad 1	23°	Condit. accept.	60°	Condit. accept.	18°	Accept.
Positioning the detector under the patient	Rad 2	41°	Condit. accept.	34°	Condit. accept.	0°	Accept.
Control of detector position	Rad 1	32°	Condit. accept.	37°	Condit. accept.	16°	Accept.
Static position waiting for the X-ray tube	Rad 3	0°	Accept.	0°	Accept.	0°	Accept.
X-ray tube manipulation	Rad 2	0°	Accept.	83°	Not accept.	-20°	Not accept.
Preparation to remove the detector from under the patient's back	Rad 2	39°	Condit. accept.	45°	Condit. accept.	0°	Accept.
	Rad 1	42°	Condit. accept.	83°	Not accept.	6°	Accept.
Patient handling to remove the detector from under the patient's back	Rad 1	30°	Condit. accept.	78°	Not accept.	9°	Accept.

Accept. = Acceptable; Condit. accept. = Conditionally acceptable; Not accept. = Not acceptable.

Figure 16 - Postures' illustrations of the medium radiographer (performer) and shorter radiographer (helper) in scenario 4: a & b) preparation to position the detector under the patient's back; c & d) patient handling to position the detector under the patient's back; e) control of detector position; f) waiting for the X-ray tube; g) X-ray tube manipulation; h & i) patient handling to remove the detector from under the patient's back; j & k) preparation to remove the detector from under the patient's back.

Table 49 - Angles measured on the medium radiographer (performer) & shorter radiographer (helper) in scenario 4.

		Trunk forward/ backward bending		Upper arm flexion/extension		Neck/Head upward/downward bending	
Activities	**Rad**	Measured angle	Obs.	Measured angle	Obs.	Measured angle	Obs.
Preparation to position the detector under the patient's back	Rad 2	54°	Condit. accept.	38°	Condit. accept.	N/M	-
	Rad 3	39°	Condit. accept.	32°	Condit. accept.	-12°	Not accept.
Patient handling to position the detector under the patient's back	Rad 2	36°	Condit. accept.	0°	Accept.	0°	Accept.
	Rad 3	24°	Condit. accept.	0°	Accept.	28°	Accept.
Control of detector position	Rad 3	30°	Condit. accept.	35°	Condit. accept.	30°	Accept.
Static position waiting for the X-ray tube	Rad 2	0°	Accept.	0°	Accept.	-18°	Not accept.
X-ray tube manipulation	Rad 2	0°	Accept.	80°	Not accept.	-20°	Not accept.
Preparation to remove the detector from under the patient's back	Rad 2	48°	Condit. accept.	24°	Condit. accept.	N/M	-
	Rad 3	42°	Condit. accept.	34°	Condit. accept.	-19°	Not accept.
Patient handling to remove the detector from under the patient's back	Rad 2	34°	Condit. accept.	0°	Accept.	15°	Accept.
	Rad 3	22°	Condit. accept.	16°	Accept.	13°	Accept.

N/M = not measurable; Accept. = Acceptable; Condit. accept. = Conditionally acceptable; Not accept. = Not acceptable.

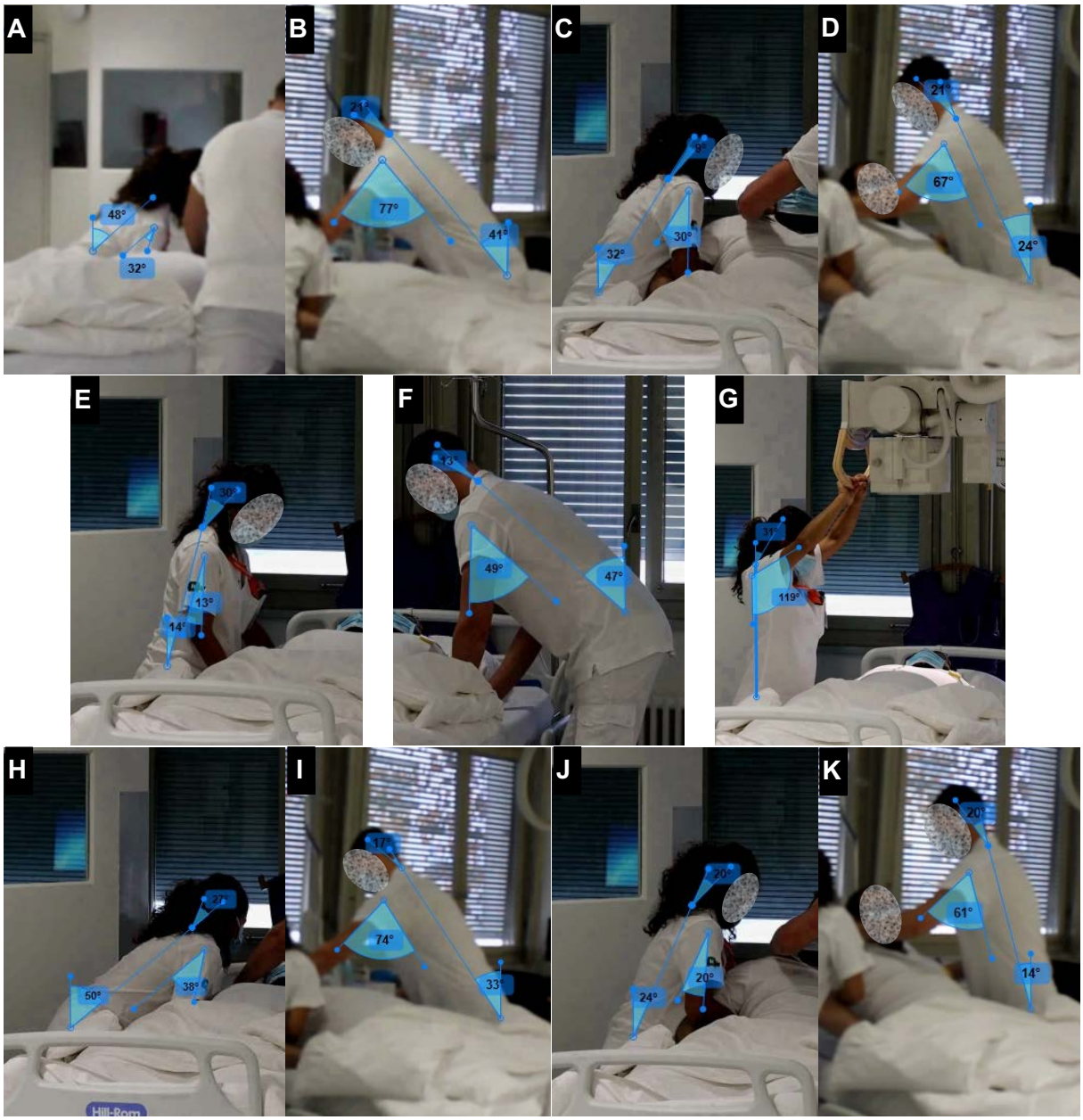


Figure 17- Postures' illustrations of shorter radiographer (performer) and taller radiographer (helper) in scenario 5: a & b) preparation to position the detector under the patient's back; c & d) patient handling to position the detector under the patient's back; e & f) control of detector position; g) X-ray tube manipulation; h & i) preparation to remove the detector from under the patient's back; j & k) patient handling to remove the detector from under the patient's back.

Table 50 - Angles measured on the shorter radiographer (performer) & taller radiographer (helper) in scenario 5.

		Trunk forward/ backward bending		Upper arm flexion/extension		Neck/Head upward/downward bending	
Activities	**Rad**	Measured angle	Obs.	Measured angle	Obs.	Measured angle	Obs.
Preparation to position the detector under the patient's back	Rad 3	48°	Condit. accept.	32°	Condit. accept.	N/M	-
	Rad 1	41°	Condit. accept.	77°	Not accept.	21°	Accept.
Patient handling to position the detector under the patient's back	Rad 3	32°	Condit. accept.	30°	Condit. accept.	9°	Accept.
	Rad 1	24°	Condit. accept.	67°	Not accept.	21°	Accept.
Control of detector position	Rad 3	14°	Accept.	13°	Accept.	30°	Accept.
	Rad 1	47°	Condit. accept.	49°	Condit. accept.	13°	Accept.
X-ray tube manipulation	Rad 3	0°	Accept.	119°	Not accept.	31°	Accept.
Preparation to remove the detector from under the patient's back	Rad 3	50°	Condit. accept.	38°	Condit. accept.	-27°	Not accept.
	Rad 1	33°	Condit. accept.	74°	Not accept.	17°	Accept.
Patient handling to remove the detector from under the patient's back	Rad 3	24°	Condit. accept.	20°	Accept.	20°	Accept.
	Rad 1	14°	Accept.	61°	Not accept.	20°	Accept.

NM = Not measurable; Accept. = Acceptable; Condit. accept. = Conditionally acceptable; Not accept. = Not acceptable.

Figure 18 - Postures' illustrations of the shorter radiographer (performer) and medium radiographer (helper) in scenario 6: a & b) preparation to position the detector under the patient's back; c & d) patient handling to position the detector under the patient's back; e) positioning the detector under the patient's back; f) control of detector position; g) X-ray tube manipulation; h & i) preparation to remove the detector from under the patient's back; j & k) patient handling to remove the detector from under the patient's back.

Table 51 - Angles measured on the shorter radiographer (performer) & medium radiographer (helper) in scenario 6.

		Trunk forward/ backward bending		Upper arm flexion/extension		Neck/Head upward/downward bending	
Activities	**Rad**	Measured angle	Obs.	Measured angle	Obs.	Measured angle	Obs.
Preparation to position the detector under the patient's back	Rad 3	36°	Condit. accept.	27°	Condit. accept.	0°	Accept.
	Rad 2	49°	Condit. accept.	91°	Not accept.	-16°	Not accept.
Patient handling to position the detector under the patient's back	Rad 3	24°	Condit. accept.	0°	Accept.	N/M	-
	Rad 2	21°	Condit. accept.	68°	Not accept.	13°	Accept.
Positioning the detector under the patient	Rad 3	41°	Condit. accept.	36°	Condit. accept.	0°	Accept.
Control of detector position	Rad 3	48°	Condit. accept.	8°	Accept.	23°	Accept.
X-ray tube manipulation	Rad 3	4°	Accept.	98°	Not accept.	16°	Accept.
Preparation to remove the detector from under the patient's back	Rad 3	36°	Condit. accept.	21°	Accept.	N/M	-
	Rad 2	54°	Condit. accept.	103°	Not accept.	-24°	Not accept.
Patient handling to remove the detector from under the patient's back	Rad 3	18°	Accept.	16°	Accept.	20°	Accept.
	Rad 2	32°	Condit. accept.	77°	Not accept.	10°	Accept.

N/M = not measurable; Accept. = Acceptable; Condit. accept. = Conditionally acceptable; Not accept. = Not acceptable.