Spinal Loading in Healthcare Staff Performing Fluoroscopic Procedures

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Summary

Back injuries are common in healthcare workers, especially for those who must wear lead aprons during procedures using fluoroscopic x-ray imaging. We developed a wearable system and loading model to measure the forces experienced throughout the spine and applied it to healthcare workers performing surgical and interventional procedures utilizing fluoroscopic imaging. Cumulative spinal loading in these healthcare workers exceeded safe daily thresholds.

Introduction

Fluoroscopic x-ray imaging is critical to many surgical and interventional procedures. For healthcare workers who perform these procedures, back injuries are common and are believed to be caused by a combination of long durations in poor postures and heavy lead aprons worn to reduce radiation exposure [1]. Cumulative loading has been shown to be a good predictor of back pain, however there is limited agreement in methods used to quantify loading and safe limits [2]. We developed a Spine Equivalent Beam (SEB) model based on the work by Xie and Lee, that uses inertial measurement unit (IMU) inputs to estimate spinal shape and calculate cumulative loading across the entire spine [3,4]. We hypothesize that healthcare workers performing surgical and interventional tasks wearing lead aprons will exceed safe daily thresholds for spinal loading

Methods

A study at Sunnybrook Health Sciences Centre (SHSC) (REB #5331) was conducted to measure cumulative loading during fluoroscopic procedures in the cardiology and orthopaedic departments. A total of 15 physicians (3 F) and 6 nurses (5 F) participated in the study. Their postures were recorded using a 4 IMU system and estimated using an arc method from [3]. To estimate cumulative load, the SEB model was applied. The SEB is an extension of the work done by Xie and Lee [4], that includes IMU input and the cervical spine. The SEB provides compressive, shear and moments continuously along the spine. From the L4/L5 compressive loading estimated by the SEB, a Mainz Dortmund dose (MDD) model was used to estimate cumulative spinal loading. [5].

Results and Discussion

The cumulative spinal load for the average reported workday of 4.9 hours was determined for each participant and mean loads were determined based on department, role, and sex (summarized in Table 1).

Table 1: Mean cumulative loading [kNh] for an 8-hour workday using a MDD model [5].

Department	Role	Male	Female	Overall
Cardiology	*Physician*	2.79	-	2.79
[N=9]	*Nurse*	1.32	1.93	1.78
	Overall	2.55	1.93	2.34
Orthopaedics	*Physician*	4.84	3.11	4.32
[N=12]	*Nurse*	-	2.70	2.70
	Overall	4.84	2.94	4.05
Combined	*Physician*	3.99	3.11	3.81
	Nurse	1.32	2.22	2.08
	Overall	3.78	2.56	3.32

The MDD model recommends a daily threshold of 0.5 kNh and 2 kNh for female and male workers, respectively. The results of our study show that thresholds are being exceeded across roles, departments, and sex with only male nurses in cardiology below the limit. These findings motivate a critical need for the development and adoption of interventions to reduce cumulative spinal loading. In addition to daily limits, Seidler et al. recommend a lifetime dose limit of 9000 kNh [6]. Given the overall average single day dose, this limit would be reached in 2711 working days, significantly less than the work life of these individuals.

Conclusions

Using the developed IMU-based system for estimating spinal loading, this work highlights the high cumulative loads experienced by healthcare workers performing surgical and interventional procedures that use fluoroscopy, that can lead to back injury, missed work and shortened careers.

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