Radiation Protective Apron Ergo Project
Marissa Christman¹, William Fan², John Fiszer³, & MaryEllen Hunt¹
¹(1) Mechanical Engineering, (2) Occupational & Environmental Health, (3) Occupational Medicine

PROBLEM STATEMENT

Long-term use of lead aprons in fluoroscopic procedures has been shown to increase back and neck pain in interventional cardiologists and electrophysiologists. Specific areas of concern are cervical spondylolisthesis and lumbar spondylolisthesis. The electrophysiology staff at a large hospital in the Intermountain West expressed concern about the potential for chronic musculoskeletal stress when using lead aprons in fluoroscopic procedures. The Manager of Corporate Industrial Hygiene Services requested a study evaluating the biomechanical stressors involved in the use of lead aprons versus the CFI Zero Gravity System (CFI Medical Solutions, Fenton, Michigan) weightless radiation protection system, which consists of a suspended body shield that provides freedom of movement, and yet can be easily engaged/disenaged relative to use of radiation, all while maintaining sterility.

This study consisted of on-site observations, as well as lab analyses which focused on using computer based models as well as EMG to estimate the back compression forces required when using a lead apron vs the CFI Zero Gravity system.

BACKGROUND & SIGNIFICANCE

The long-term use of lead aprons in medical procedures is thought to cause spinal problems in physicians and their support staff. Practitioners wear lead in procedures involving the use of radiation (fluoroscopy). In electrophysiology procedures, radiation is only used in for about 5-7 minutes out of the entire 1-3 hour procedure time. In order to maintain sterility throughout the procedure, however, physicians and nurses typically remain in their lead aprons throughout their entire workday, instead of taking their lead off when radiation is not being used in the lab. The Zero Gravity System (ZGS) provides freedom of back/spinal problems in their ranks as an “epidemic”, with rates of back/spinal disease significantly higher than in the general U.S. population.

METHODS

Field Observation

Observations and interviews of Electrophysiology Lab staff and procedures were conducted. Data included:
- Staff feedback on:
  - The ergonomic demands of the job
  - Information on the frequency and duration of procedures
  - The most frequently observed musculoskeletal complaints as a group related to the task
  - The frequencies of staff and physicians for radiation-shielding garments
  - The preferences of physicians for type of equipment used during procedures (i.e. standard manual catheter navigation, remote magnetic catheter navigation, Stereotaxis, etc.)
- Photographic recording of staff and physician postures

Biomechanical Analysis

The primary static postures which were observed were replicated in the University of Utah Mechanical Engineering Ergonomics and Safety Lab using a single participant. Lower back compressive forces expressed as a function of erector spinae electromyographic (EMG) activity was the primary evaluation of the qualitative analysis of the back/spinal postures typically required during the procedures performed. Two task conditions were considered (i.e. 1) wearing a traditional radiation-shielding apron and 2) utilizing the CFI Zero Gravity radiation-shielding system, both of which are shown below).

RESULTS & DISCUSSIONS

The following calibration curves of Back Compressive Force vs. EMG per torso posture were generated using loads of 0, 5, 8, 10, and 15 Ib:

Collection was completed via the following procedures:
- Placed EMG sensors on target muscles of a participant
- Placed a series of known loads in the participant’s hands and recorded the EMG results per load condition for three postures shown below (upright, 30 degrees flexed, 60 degrees flexed)

From these curves the BCFs (seen in the table below) were predicted for each posture in the load and in the Zero Gravity system. All of the results are below the NIOSH 770 lb Action Limit, as the loads involved in both shielding situations are not high. It should be noted that the CFI is less stressful in both of the flexed positions.

CONCLUSIONS & RECOMMENDATIONS

Relevant factors for EP staff associated with back disorders include:
- Poor posture
- Staying in one position for too long
- Poor physical condition
- Maintaining bent postures
- Fatigue

This study didn’t elucidate the complete ergonomic impact of the lead and ZGS. Typical radiation-shielding garments create small loads and small moments on the body. This in turn does not produce significant data points when compared to the control situation of no shielding.

It is difficult to measure true trunk angle. (The measurements in this study were a simplified assessment of trunk inclination that combined both lumbar and sacral movements simultaneously.)

This study’s data doesn’t effectively predict potential muscle fatigue issues or disorders related to repetitive stresses.

Until more tailored and definitive research can be carried out, recommendations are as follows:
- Consider if operating room tables can be adjusted for varying staff heights during procedures.
- Assist employees in learning posture awareness and train in basic ergonomic principles and recognition of hazards and injuries.

REFERENCES


ACKNOWLEDGEMENTS/CONTACTS

Many thanks go out to the following individuals for their contribution to our project:
- CFI Medical Solutions, Fenton, Michigan
- Participating hospital in the Intermountain West