Work-related Musculoskeletal Disorders in Radiation Therapists:
An Exploration of Self-Reported Symptoms

Thesis

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the Graduate School of The Ohio State University

By
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Abstract

This study explores the self-reported symptoms of musculoskeletal disorders in Radiation Therapists (RTT) registered by the American Registry of Radiologic Technologists (ARRT), in the United States. There was a gap in the literature focusing on RTTs unique set of workplace injuries. Utilizing a nationwide survey the anatomical areas where the most RTTs experienced pain were discovered along with other demographic factors in order to seek relationships between this demographic data with the occurrence of musculoskeletal symptoms. Different aspects of perceived physical and mental demand will also be discussed. Suggestions for possible future directions to ameliorate this problem will also be discussed, such as ergonomic training. The multivariate interaction theory describes how injury causation is due to biomechanical hazards in the workplace. This explains how movements while transferring or positioning patients for treatment has the potential for RTTs to incur musculoskeletal injuries. Data was collected by administering a nationwide online survey to a large convenient sample of RTTs. The instrument contained questions about what common work related symptoms are encountered in the profession. Data analysis allowed for exploring some relationships between different variables, their occurrence, and the anatomical site of musculoskeletal symptoms.
Acknowledgements

I would like to thank the members who served on my thesis committee, Dr. Carolyn Sommerich and Dr. Maryanna Klatt for their time and expertise on this thesis and for their commitment to bettering the working conditions and lives of radiation therapists.

I would also like to thank the American Registry of Radiologic Technologists for providing our sample in order to complete this research.

I am also very indebted to my advisor Dr. Kevin Evans who believed in me the whole way through this opportunity and always made time for me. Thank you for your guidance and knowledge to propel me into becoming a better scholar and contributor to my profession.
Vita

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Fields of Study

Major Field: Allied Medicine, Radiation Therapy, Healthcare Management
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Chapter 1. Introduction

Background and Significance

Radiation Therapists (RTTs) are at the front line in the betterment of the lives of cancer patients every day. Patients have put their trust in RTTs to provide accurate and compassionate care. In order to ensure accurate treatment, patients must be manually positioned on designated markers by RTTs on a table that is raised high in the air at the treatment isocenter. This causes the RTT to move and adjust patients while the patient is elevated above the RTTs waist. This puts the RTT at a biomechanical disadvantage by working with their hands above the shoulder level. The multivariate theory describes these kinds of biomechanical hazards such as exerting excess force, performing repetitious activity, and assuming postures for extended time contributors to injury causation.\(^1\) These daily tasks performed by the RTT could result in the development of painful musculoskeletal symptoms. These musculoskeletal symptoms can lead to possible career ending injuries and have a negative fiscal impact by reduced productivity, missed days of work, and worker’s compensation claims. This study explored common sites of musculoskeletal symptoms in RTTs in order to promote injury prevention initiatives that can be targeted to specific anatomically effected areas.
Statement of the Problem

Work-related musculoskeletal disorders (WRMSD) are attributed to injuries that can take place for an RTT who needs to work with patients in a position of biomechanical disadvantage, such as lifting and adjusting patients on an elevated treatment table. To deliver an effective radiation treatment, a patient must be positioned within millimeters of how they were planned to be treated. Because of the precision involved in radiation therapy, a great deal of microscopic manipulation is required to set up each patient appropriately for treatment. Therefore, repetitive positioning can lead to injury over time and possible debilitating injuries for the RTT. In addition to patient positioning, other physical work obligations include lifting cumbersome equipment, transferring patients from a cart or wheelchair, lifting metal blocks, and operating machine controls. Not only do musculoskeletal pain and disorders contribute to lasting effects on a professional’s quality of life, it can lead to ill time used, cost to the employer, and unproductive working hours. Registered nurses (RNs) have been the focus of many of these kinds of studies, as it relates to transferring and repositioning patients. None the less, RTTs provide a valuable service to patients and their work-related injuries are equally important to understand and mitigate. There is a gap of knowledge as to the type and severity of RTTs’ injuries and minimal ergonomic education has been provided by educators and/or by the employers.
Literature Review

Work-related musculoskeletal disorders (WRMSDs) occurring among RTTs could have major health impacts. Physical demands that are placed on RTTs could put stress on bones, muscles and joints that could result in personal injuries. These demands can lead to chronic physical ailments with direct and indirect costs to the worker and to their employers. According the Bureau of Labor Statistics in 2016, there were approximately 19,100 registered RTTs. The job growth over the next ten years is projected to increase 13%, which is considered much faster than the average job growth. During this time of increased growth, along with an aging workforce, it is imperative to understand the implications of certain work tasks that may contribute to a RTTs’ daily work and also translate into an increased risk factors for WRMSDs.

Occurrence and costs of WRMSDs

The Occupational Safety and Health Administration (OSHA) has brought issues of increasing WRMSDs to the forefront, releasing data that over exertion and bodily reaction make up 48% of injuries among hospital workers in a 2011 study. Reviewing the total injuries that resulted in requested days off, sprains and strains accounted for 54% of time taken away from work. Some personal contributing risks associated with an increased risk for injuries includes an aging workforce coupled with an increase in obesity. These factors also pose challenges for RTTs who have to work with older and heavier patients that need to be manually positioned and transported. OSHA’s report also highlights the costs of these injuries. One of the costs emphasized is an average of
$15,860 for every workers’ compensation claim. This expense has direct impact on the employer’s expected revenue, as a result of these type of claims.³

WRMSD Causation in the Workplace

Nursing is a common healthcare occupation that is studied for risk factors of WRMSDs. Florentino et al. (2012) studied RNs using a survey, with a detailed body map, and associated pain symptoms that were thought to be associated with various nursing tasks.⁴ It was noted that when considering common nursing tasks, a correlation existed between specific nursing tasks and the areas of the body where pain was reported.⁴ Because the number of RNs far outnumbers the number of RTTs in a hospital setting, this study and many others have examined injuries exclusive to RNs. While meaningful for the nursing field, these studies are not applicable to work performed by RTTs. However, these studies do not provide recommendations on how other hospital workers, such as RTTs, can reduce the risk of work-related injuries, specific to their work tasks. Some differences exist between the muscle and skeletal movements of RNs and RTTs. One difference is the way RTTs position patients for a radiation therapy treatment. Once a patient is elevated on a treatment table, they will likely need to be adjusted, using a laser alignment system. This laser guidance ensures that the patient is positioned within millimeters of how their original treatment was originally planned. This requires manual manipulation of a patient, whether that be shifting their body to one side, moving them superior or inferior, or rolling their body to make them level and get them on their designated treatment marks. Patients are instructed to lay still and not assist in order for RTTs to move them just enough to ensure their proper positioning. When adjusting
patients with the treatment table elevated, the RTT’s leverage is not ideal and the shoulders, upper extremities, upper neck, and back can be strained (See Fig 1). This positioning is done for every patient a RTT sets up every day and many movements are repetitive.

![Fig. 1 RTTs working with a patient on the elevated treatment table. All adjustments for patients are guided by the use of a laser light to indicate the isocenter.](image)

Outside of the studies done on RNs in a healthcare setting, a study done by Kim and Roh analyzed WRMSDs among radiologic technologists (RTs). The study used videotaped sessions to analyze the common movements made by RTs and scored the RTs with the Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), the National Institute for Occupational Safety and Health Lifting Equation (NLE), and Strain Index (SI). Having these movements quantified was helpful in determining what were the common movements made by RTs and the potential cause of their pain symptoms. The study findings concluded that the distance between the RT and what they were moving caused increased risk for injury of the neck and shoulders. Similarly the lower back was also noted to be greatly affected from bending motions and
the extra strain this caused for the lumbar spine. Additionally it was concluded that workers engaging in heavy lifting, lowering, and moving should have proper education and training before they start working. This should also include exercises for preventing lower back pain and knowing proper working body postures. This study was limited to RTs in one hospital in Korea and was exclusive to those RTs who provided MRI examinations as well as Diagnostic Medical Sonographers (DMS).

Research in this area was scant and often the occupation of RTT was lumped into other imaging disciplines such as Radiography (RT). A group of articles were produced in the early 1990s that indicated that RTs were at risk for low-back pain and injury. These studies were surveys of hospital workers of which, RTs and possibly RTTs were a subset of the sample. The small subset of RTs reported pain and injury but this would reflect the duties being performed prior to implementation of modern imaging and therapy equipment. Fortunately, renewed research on RTs exposure to work-related injuries was championed by Kumar et al. In a series of studies, designed as both survey and observational, Kumar’s group recruited RTs from two different hospital systems. In this work, the researchers were able to survey a random sample of 20 RTs from a pool of 109 RTs, from the 2 hospital systems. With their survey they found 83% of their respondents reported back pain in addition to female RTs listing neck and shoulder pain as significant. Even more concerning was that 50% of the female RTs reported having upper extremity pain. A more detailed analysis of the surveys revealed a list of those tasks that the respondents associated with their work-related pain. When asked about their back pain, 78% of the female RTs attribute this to be due to manually lifting patients.
from the wheelchair as well as 67% indicated that manually transferring spine board patients to the radiographic table.\textsuperscript{13} This set of studies was further strengthened by the researchers gathering video and measuring physical loads that RTs were exposed to in performing their tasks. This dated research, which included RTs and an assumed unspecified subset that performed RTT duties, was in need of renewed investigation and specific data for the RTT profession.

While RTTs are often considered a subset of radiologic workforce, they do share some of the same common movements. However there are some movements that are explicit to RTTs that were not analyzed (See Fig. 2. RTT neck position to view varied monitors). Evaluating movements by using the assessment tools in this study could add information to the body of knowledge examining risk factors for RTTs specifically.

![Fig. 2. RTT having to work with monitors at varied heights for both the treatment, viewing the patient, and using the PC. This requires moving the head and neck to varied positions to view all the monitors mounted at different heights.](image)
In terms of proper training and education, Marras et al (1999) analyzed the movements of a variety of different patient transfer and repositioning techniques.\textsuperscript{14} Regardless of proper technique or the utilization of one or two workers to assist with the patient, the risk for low back disorders associated with these movements was high in a best case patient scenario.\textsuperscript{14}

**Safe Patient Handling Alternatives**

Using good body mechanics is not the only intervention that should be considered as a means to reduce the risk of WRMSDs. A critical literature review done by Mayeda-Letourneau et al. studied safe patient handling and movement using different factors like an engineering intervention of ceiling lifts, administrative interventions of patient handling procedures, assessment protocols, and behavioral interventions of education and training staff.\textsuperscript{15} This safe patient handling and movement program decreased work injury costs overall and improved job satisfaction with employees feeling the support of their employer.\textsuperscript{15} Creating a culture of safety where hospital administration supports employee education and promotes employee safety is vital. It further demonstrates to the employee the importance of being safe and avoiding risky behaviors.

**Psychosocial Factors in Combination with WRMSDs**

Along with physical risk factors at work, a set of non-physical risk factors have been identified as contributing to the risk of WRMSDs. Macdonald and Oakman explored psychosocial hazards being additive or interactive with physical hazards.\textsuperscript{16} Psychosocial hazards include factors related to job content, workload and pace, schedule, control, culture of the organization, interpersonal relationships at work, role in
organization, career development, and home-work interface. Macdonald, et al. compared workplace factors (both physical and psychosocial) in combination with individual factors such as work related skills, abilities, personality, and genetic vulnerabilities. With an infinite number of combinations between these workplace and individual factors, causal effects of WRMSDs can present differently in individuals depending on their stress response to the biomechanical load and their level of fatigue or internal tolerances. This makes for complication when reviewing self-reported levels of pain without also exploring factors beyond those that are considered to be physical. The pre-existing health of the individual is a contributing factor to the risk of developing a WRMSD. The health of a worker needs to be assessed so that other types of WRMSD assessments can be considered applicable to other RTTs in the workplace.

Another study done by Hayes et al. also explored the multifactorial causes of WRMSDs in dental hygienists. The researchers found that several risk factors existed in both the work-related and psychosocial categories. There was a distinct association between two factors individuals reported that resulted in lower levels of WRMSDs. The first was receiving education in ergonomics and the other was higher wage satisfaction. Other factors, such as control over the job and psychological demand of work were studied by Barzideh, et al., as it relates to WRMSDs. The perception of an employee as to their psychosocial support or lack of support, could impact their risk for WRMSDs. The multifactorial impact on the risk for WRMSDs, would suggest that a comprehensive approach is needed in order to effectively reduce injuries. In the study provided by Hayes
et al., it would appear that education specific to ergonomics worked in concert with other factors to reduce the risk for WRMSD.\textsuperscript{17}

Another psychosocial consideration for these RTTs specifically working with an oncologic population is the inherent risk of compassion fatigue and burnout that has been studied in oncology nurses that have higher levels of these risks as the years in the field increases.\textsuperscript{19} While these psychosocial studies have not been explicitly performed on RTTs, the patient population and time spent is similar and can further exacerbate work related stress.

**Summary**

The occupation of RTT has not been specifically studied to discover what anatomical areas work related pain is occurring. They work under physically and emotionally demanding circumstances and the gap of knowledge for this profession should be studied. Based on other studies done in the healthcare field with similar risk factors, there is reason to investigate any factors surrounding RTT work related pain. Multifactorial considerations should be made including those in both the physical and psychosocial realms.
Objective

The purpose of this study was to explore the common areas of musculoskeletal discomfort in RTTs. Identifying specific anatomical sites that were most painful, could assist employers and educators to focus their efforts on targeted prevention. Specifically efforts that might include education on the use of ergonomic techniques and how to use engineering controls such as mechanical lifts that could reduce the risk of musculoskeletal disorders. Providing education to employees on ergonomic techniques and specific engineering controls could lead to a reduction employer expense such as sick leave and disability payments. It could conversely increase worker productivity, raise their quality of life, and positively impact job satisfaction. A survey to collect self-reported pain and injury data was used for a sample of RTTs who were registered with the American Registry of Radiologic Technology (ARRT), in the United States. With demographic, psychosocial, and work attendance data combined with musculoskeletal symptom data, relationships between different variables were analyzed for frequency and specific detail. This data could be used to identify specific anatomic areas which could be targeted for a reduction in musculoskeletal symptoms.
Research Questions

1. How many radiation therapists (RTT) are working while in pain?
   a. Which areas of the body are identified as areas of discomfort among RTT?
   b. What relationships exist between psychosocial data and occurrence of painful musculoskeletal symptoms?

2. What types of patients are perceived as physically demanding?

3. What relationships exist between pace of work and musculoskeletal pain?

4. How often do RTTs miss days of work as a result of an on the job injury?
Definition of Terms

Constitutional Definitions

1. **Ergonomics** – the study of the interaction between humans and their working environment as a way to minimize the incidence of injury or long term effects from poor working environments.

2. **Musculoskeletal System** – provides form, support, stability and movement to the body. It is comprised of bones, muscles, cartilage, tendons, ligaments, joints, and other connective tissue that makes up the supportive structure of the body.

3. **Radiation Therapist** – A registered member of the American Registry for Radiologic Technologists (ARRT) that has an active license to practice radiation therapy.

4. **Work-Related Musculoskeletal Disorder** – a group of painful disorders of components of the musculoskeletal system including muscles, tendons, and nerves. In RTTs, they are specifically those that develop gradually and are caused by the overuse of the previously listed elements of the musculoskeletal system. Frequent and repetitive tasks and activities with awkward postures are contributable factors.

Operational Definitions

1. **Patient Positioning** – positioning a patient for radiation treatments involving manual manipulation of a patient’s body to align their treatment area utilizing setup marks and a laser alignment system (See Fig 3).
2. *Musculoskeletal pain* – pain that is associated with the musculoskeletal system which was measured using survey questions targeting specific body parts, as defined by the Nordic musculoskeletal questionnaire. 20
Theoretical Framework

Work related musculoskeletal injuries are biomechanical in nature, meaning that a worker’s body is at risk for injury as they complete their job duties. The body’s muscles exert force, and the skeletal structure fights gravity in order to accomplish physical work, as defined by the multivariate interaction theory.¹ This theory is dependent on an individual’s components and their mechanical properties (See Fig 4).¹ The one specific individual component of multivariate interaction theory, “biomechanical hazards that an occupation presents,” is the most applicable for explaining these work related injuries. Disruption of this factor can cause stress and ultimately injury to the body. When the demand on the body is to exert an excessive force, perform repetitious activities, or assume postures for extended time, the human muscle and skeletal system are stressed. This may have long term negative consequences on a worker’s health.

Figure 4. Kumar’s model of multivariate interaction theory¹
The main parts of the multivariate interaction theory include an individual’s genetic endowment, morphological characteristics, psychosocial work factors, and the specific occupational biomechanical factors.\(^1\) For the purpose of this study, the concern was on the biomechanical factors and the psychosocial makeup of RTTs. It was also important to record the anatomical site of their pain and relate those to specific RTT work/pain behavior. In the psychosocial aspect of the theory, questions on the survey were devoted to job stress, mental demand, and perceived work pace which can contribute to work-related injuries. Also, since workplace injuries are multi-faceted, as illustrated by the multivariate theory, it would be important to focus on additional factors beyond just physical exertion.

**Methodology**

**Research Design**

This quantitative survey research utilized demographic data, Likert scale items, multiple choice questions, and visual analogue scales. The survey instrument collected varied demographics in order to categorize RTTs and compare these different aspects to the prevalence of musculoskeletal disorders. Some examples of these demographic items include: gender, age, weight, height, number of years worked in the profession, and average time taken to treat a patient, and number of patients treated per day. The survey also utilized a modified Nordic Musculoskeletal Questionnaire that is a valid and reliable instrument to identify musculoskeletal symptoms per body site.\(^20\) The questionnaire divided a picture of the human body into nine different areas including the neck, shoulders, elbows, upper back, lower back, wrists/hands, hips/thighs, knees, and ankles/feet for the purpose of identifying common body sites that are symptomatic.\(^20\) For
each of the nine anatomically designated areas, a forced choice question was used to assess the presence or absence of pain symptoms that have occurred in the last 12 months. To avoid recall bias, 12 months was the longest amount of time for participants to recollect data. Other questions in the psychosocial categories included “how satisfied are you with your job?”, “Do you report pain to your manager?”, and “how mentally demanding is your job?” The Qualtrics software program was utilized to create and distribute the survey to the random sample of RTTs. Qualtrics is the current standard survey tool for The Ohio State University’s School of Health and Rehabilitation Sciences. The survey went through a pilot testing phase with RTTs at The Ohio State University Medical Center. A comprehensive cover letter was prepared for distribution to the nationwide survey sample and participants were selected from the ARRT registry database.

Sampling

The researchers sent out the electronic survey to 2,416 ARRT registered RTTs that indicated a willingness to participate in research. The researchers aimed for a 30% response rate. The ARRT selected a frame of 2,416 RTT registrants that were maintained in their registry database, for the purpose of this study. The survey was sent out to all those RTTs in the frame, no matter of what their experience is or in what type of settings in where they are practicing. The survey was accessed online and an invitation was sent out via email with a link provided. An informed consent attachment was completed before the survey was administered. Data collected from the survey included demographic information such as gender, age, weight, height, and also the number of years worked in the profession, and average number of hours per shift and per week. For
specific musculoskeletal pain, the survey utilized a modified version of the Nordic questionnaire that has body regions highlighted and asks about frequency and areas of pain. The body areas include the neck, shoulders, elbows, upper back, lower back, wrists/hands, hips/thighs, knees, and ankles/feet. Participants identified if they had experienced pain or discomfort during the last year.

**Instrumentation**

The instrument used in this study was a modified version of the Nordic Musculoskeletal questionnaire, combined with demographic data. This qualitative tool was used to assess the frequency and location of musculoskeletal symptoms. By looking at several different areas that are commonly effected by musculoskeletal pain symptoms and comparing different demographics and other sources of causes in order to find trends.

**Survey**

A modified version of the Nordic Musculoskeletal Questionnaire (NMQ) was used. The survey had a combination of demographic information, NMQ, and psychosocial inquiries. The NMQ has been tested for reliability using a test-retest methodology and has been validity tested against clinical history. It is deemed useful as a tool for screening and surveillance, but not to diagnose disorders. The complete survey can be found in Appendix A.

**Data Collection and Analysis Procedures**

An electronic consent form was required to submit before the survey was initiated. The survey was pilot tested in order to insure that the wording was appropriate
for RTTs and that the survey worked correctly. All survey data was captured by the Qualtrics program for analysis along with faculty support from the Department of BioStatistics at The Ohio State University.

**Protection of Human Rights**

This survey research was approved by The Ohio State University’s Internal Review Board for administration. Participation in this study is on a voluntary basis. Participants were consented before taking the survey and have the option to withdrawal at any point. All subjects’ surveys were confidential and anonymized. Upon completion of the study, participants were eligible to receive a copy of the survey.
Chapter 2. Results

The survey instrument was administered through an online format and e-mail invitations were provided to a frame of Radiation Therapists (RTT), registered with the American Registry of Radiologic Technology (ARRT). The survey was made available for 3 months and then closed for further participation. The result was that 243 RTTs agreed to participate in the study. From the consented cohort of 243 RTTs, 222 were considered eligible (203 full time and 18 part time), as they had begun to complete the survey instrument. Only 162 RTTs out of the total 222 subjects completed the survey in its entirety. Therefore, this analysis is based on the 162 RTTs who completed the entire survey instrument. The response rate based on the 162 RTTs fully completing the survey and the total of 2416 RTTs that were sent the survey made the completion rate 6.7%.

Demographics

The cohort of RTTs who participated in this survey were divided into descriptive categories for further analysis. This cohort was divided into 74% female and 26% male. The majority of those RTTs who completed the survey were greater than 30 years of age, with the highest percentage (32%) of RTTs being further subdivided as being 50 years and older. Extending the descriptive analysis, it was important to record the distribution of the RTTs length of work in the occupation. To that end, most of the RTTs surveyed (29%) had been working in the profession for over 21 years. For a complete breakdown of the frequency of the demographic information, please see Table 1.
Self-reported pain.

This same cohort of RTTs were queried about the level of pain that they experience as it relates to their occupational duties. Based on the 162 RTT respondents, 81.5% of respondents reported that they experienced pain while working. For the data related to self-reported pain, please see Table 2.

Table 1: The demographics of Radiation Therapists that completed the survey instrument.

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>120</td>
<td>74.07</td>
</tr>
<tr>
<td>Male</td>
<td>42</td>
<td>25.93</td>
</tr>
<tr>
<td><strong>current age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>18</td>
<td>11.11</td>
</tr>
<tr>
<td>30-39</td>
<td>48</td>
<td>29.63</td>
</tr>
<tr>
<td>40-49</td>
<td>44</td>
<td>27.16</td>
</tr>
<tr>
<td>50 and above</td>
<td>52</td>
<td>32.1</td>
</tr>
<tr>
<td><strong>Years of current occupation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 3 years</td>
<td>7</td>
<td>4.32</td>
</tr>
<tr>
<td>3-5 years</td>
<td>24</td>
<td>14.81</td>
</tr>
<tr>
<td>6-10 years</td>
<td>32</td>
<td>19.75</td>
</tr>
<tr>
<td>11-15 years</td>
<td>29</td>
<td>17.9</td>
</tr>
<tr>
<td>16-20 years</td>
<td>23</td>
<td>14.2</td>
</tr>
<tr>
<td>21 or more years</td>
<td>47</td>
<td>29.01</td>
</tr>
</tbody>
</table>
Table 2. Radiation Therapists who self-reported pain during performance of their duties.

<table>
<thead>
<tr>
<th>Experienced Pain</th>
<th>Count</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>30</td>
<td>18.52</td>
</tr>
<tr>
<td>Yes</td>
<td>132</td>
<td>81.48</td>
</tr>
</tbody>
</table>

To further refine the information provided on self-reported pain, we asked RTTs to indicate the anatomical area of the body where they experienced work-related musculoskeletal pain. A representative body map is provided as Figure 4, which demonstrates the cohort’s anatomical areas of complaint. The majority of RTTs stated that their pain was located in the following sites: low back (78%), neck (76%), and shoulders (73%).
### Physical Demand

A set of survey questions were provided to gauge the physical demand that RTTs experience in the performance of their occupational duties. A majority of RTTs responded that they did greater than 19 treatments or procedures in a normal workday, with most of these treatments or procedures taking 11-15 minutes. The type of patients that were perceived to elicit the most physical demand were elderly patients. The next most physically demanding patients were the heavy or obese patients. A listing of physical demanding patient types is provided as Table 3. The overall perception of
physical demand was 71.5 on a scale of 0-100, with a standard deviation of 24.9. The complete frequency listing of the cohorts’ response for physical demand is listed in Table 4.

Table 3. Radiation Therapists’ indication of the most physical demanding patient types.

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Percentage ± Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elderly patients</td>
<td>43.7% ± 21.3</td>
</tr>
<tr>
<td>Heavy or obese patients</td>
<td>26.1% ± 17.6</td>
</tr>
<tr>
<td>Physically impaired patients</td>
<td>15% ± 13.7</td>
</tr>
<tr>
<td>Patients who are much shorter than me</td>
<td>5.5% ± 9.2</td>
</tr>
<tr>
<td>Patients who are much taller than me</td>
<td>6.7% ± 11.1</td>
</tr>
<tr>
<td>Other</td>
<td>3.2% ± 11.3</td>
</tr>
</tbody>
</table>

Table 4. Radiation Therapist’s self-reported occupational physical demands.

<table>
<thead>
<tr>
<th>Number of treatment Per day</th>
<th>Count</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>4.94</td>
</tr>
<tr>
<td>1-5</td>
<td>6</td>
<td>3.7</td>
</tr>
<tr>
<td>6-8</td>
<td>3</td>
<td>1.85</td>
</tr>
<tr>
<td>9-11</td>
<td>3</td>
<td>1.85</td>
</tr>
<tr>
<td>12-14</td>
<td>5</td>
<td>3.09</td>
</tr>
<tr>
<td>15-18</td>
<td>29</td>
<td>17.9</td>
</tr>
<tr>
<td>&gt;=19</td>
<td>108</td>
<td>66.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minutes Per treatment</th>
<th>Count</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>than 10 minutes</td>
<td>8</td>
<td>4.94</td>
</tr>
<tr>
<td><strong>11-15 minutes</strong></td>
<td><strong>81</strong></td>
<td><strong>50</strong></td>
</tr>
<tr>
<td>16-20 minutes</td>
<td>51</td>
<td>31.48</td>
</tr>
<tr>
<td>21-25 minutes</td>
<td>5</td>
<td>3.09</td>
</tr>
<tr>
<td>26-30 minutes</td>
<td>4</td>
<td>2.47</td>
</tr>
<tr>
<td>31-45 minutes</td>
<td>6</td>
<td>3.7</td>
</tr>
<tr>
<td>than 45 minutes</td>
<td>7</td>
<td>4.32</td>
</tr>
</tbody>
</table>

Physical Demanding perception* 71.5 ± 24.9
Mental Demand

This cohort of RTT’s perceived their work to be very mentally demanding, with a score of 80.4 based on a scale of 0-100 with a 21.6 standard deviation. Those stating they worked at a hurried or rushed pace had a score of 71.9, based on a scale of 0-100 with a standard deviation of 24.5. Most RTTs indicated that they were somewhat satisfied when asked what their overall job rating. Their job satisfaction score was a 3 based on a job satisfaction rating scale of 1-4. The complete listing of the RTT’s frequency of data for mental demand is provided in Table 5.

Table 5. Radiation Therapists’ perception of the occupational mental demands.

<table>
<thead>
<tr>
<th>Mentally demanding perception*</th>
<th>80.4 ± 21.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>hurried/rushed pace*</td>
<td>71.9 ± 24.5</td>
</tr>
</tbody>
</table>

Job Satisfaction

| Not at all satisfied | 2 | 1.23 |
| Not very satisfied   | 16| 9.88 |
| **Somewhat satisfied** | **83** | **51.23** |
| Very satisfied       | 61| 37.65 |

Table legend:* 0 to 100 with 100 as extreme

Demographics of those working in pain.

The most RTTs that reported pain were those who had 3-5 years of experience (91.7%) There was also greater than 80% pain reported in the categories of greater than 11 years of experience. The complete documentation of the frequency for those RTTs who were working in pain is provided in Table 6.
Table 6. Demographic data of those Radiation Therapists reporting working in pain

<table>
<thead>
<tr>
<th>Years of Experience</th>
<th>No Pain</th>
<th>Pain</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>30 (18.5%)</td>
<td>132 (81.5%)</td>
<td>162 (100%)</td>
</tr>
<tr>
<td>Less than 3 years</td>
<td>3 (42.9%)</td>
<td>4 (57.1%)</td>
<td>7 (4.3%)</td>
</tr>
<tr>
<td>3-5 years</td>
<td>2 (8.3%)</td>
<td>22 (91.7%)</td>
<td>24 (14.8%)</td>
</tr>
<tr>
<td>6-10 years</td>
<td>8 (25%)</td>
<td>24 (75%)</td>
<td>32 (19.8%)</td>
</tr>
<tr>
<td>11-15 years</td>
<td>4 (13.8%)</td>
<td>25 (86.2%)</td>
<td>29 (17.9%)</td>
</tr>
<tr>
<td>16-20 years</td>
<td>4 (17.4%)</td>
<td>19 (82.6%)</td>
<td>23 (14.2%)</td>
</tr>
<tr>
<td>21 or more years</td>
<td>9 (19.2%)</td>
<td>38 (80.9%)</td>
<td>47 (29%)</td>
</tr>
</tbody>
</table>

Physical demands of those working in pain

Those working in pain were providing patient services at a rate of greater than 12 treatments or procedures and spending 11-20 minutes or greater than 31 minutes on each case. The physical demand perception on a scale of 0-100, was 74.5 for those working in pain. Among those RTTs who were working in pain compared to those who weren’t, the physical demand was rated lower for those not working in pain at 58.2. The complete listing of physical demands for those RTTs who were working in pain is provided in Table 7.

Mental Demands of those working in pain

The perception of the mental demand was similar between those RTTs who were reporting that they worked in pain with an 80.7 score, compared to RTTs not working in pain that reported a score of 79. The perception of a hurried work pace was higher for those working in pain with a score of 73.5 compared to a 65.2 for those RTTs not working in pain. In terms of job satisfaction, most people were still either somewhat satisfied or very satisfied regardless of working in pain. However 93.8% of those RTTs that were not very satisfied with their jobs were those who reported that they experienced
pain while working. A complete listing of the RTT responses to mental demands among those working in pain is listed in Table 8.

*Table 7. Physical demand categories of those Radiation Therapists reporting working in pain.*

<table>
<thead>
<tr>
<th>Number of treatment Per day</th>
<th>No pain</th>
<th>Pain</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3 (37.5% )</td>
<td>5 (62.5% )</td>
<td>8 (4.9% )</td>
</tr>
<tr>
<td>1-5</td>
<td>2 (33.3% )</td>
<td>4 (66.7% )</td>
<td>6 (3.7% )</td>
</tr>
<tr>
<td>6-8</td>
<td>0 (0% )</td>
<td>3 (100% )</td>
<td>3 (1.9% )</td>
</tr>
<tr>
<td>9-11</td>
<td>1 (33.3% )</td>
<td>2 (66.7% )</td>
<td>3 (1.9% )</td>
</tr>
<tr>
<td>12-14</td>
<td>0 (0% )</td>
<td>5 (100% )</td>
<td>5 (3.1% )</td>
</tr>
<tr>
<td>15-18</td>
<td>7 (24.1% )</td>
<td>22 (75.9% )</td>
<td>29 (17.9% )</td>
</tr>
<tr>
<td>19 and above</td>
<td>17 (15.7% )</td>
<td>91 (84.3% )</td>
<td>108 (66.7% )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Min per treatment</th>
<th>No pain</th>
<th>Pain</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10 minutes</td>
<td>3 (37.5% )</td>
<td>5 (62.5% )</td>
<td>8 (4.9% )</td>
</tr>
<tr>
<td>11-15 minutes</td>
<td>13 (16.1% )</td>
<td>68 (84% )</td>
<td>81 (50% )</td>
</tr>
<tr>
<td>16-20 minutes</td>
<td>9 (17.7% )</td>
<td>42 (82.4% )</td>
<td>51 (31.5% )</td>
</tr>
<tr>
<td>21-25 minutes</td>
<td>2 (40% )</td>
<td>3 (60% )</td>
<td>5 (3.1% )</td>
</tr>
<tr>
<td>26-30 minutes</td>
<td>1 (25% )</td>
<td>3 (75% )</td>
<td>4 (2.5% )</td>
</tr>
<tr>
<td>31-45 minutes</td>
<td>1 (16.7% )</td>
<td>5 (83.3% )</td>
<td>6 (3.7% )</td>
</tr>
<tr>
<td>more than 45 minutes</td>
<td>1 (14.3% )</td>
<td>6 (85.7% )</td>
<td>7 (4.3% )</td>
</tr>
</tbody>
</table>

**Physical demanding perception*** 58.2 ± 29    74.5 ± 22.9

Table legend:* 0 to 100 with 100 as extreme
Table 8. Mental demand aspects of those Radiation Therapists reporting working in pain

<table>
<thead>
<tr>
<th>Mentally demanding perception*</th>
<th>No Pain</th>
<th>Yes Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>79 ± 22.7</td>
<td>80.7 ± 21.4</td>
</tr>
</tbody>
</table>

| Hurried perception* | 65.2 ± 26 | 73.5 ± 23.9 |

<table>
<thead>
<tr>
<th>Job Satisfaction</th>
<th>No Pain</th>
<th>Yes Pain</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all satisfied</td>
<td>0 (0% )</td>
<td>2 (100% )</td>
<td>2 (1.2% )</td>
</tr>
<tr>
<td>Not very satisfied</td>
<td>1 (6.3% )</td>
<td>15 (93.8% )</td>
<td>16 (9.9% )</td>
</tr>
<tr>
<td>Somewhat satisfied</td>
<td>11 (13.3% )</td>
<td>72 (86.8% )</td>
<td>83 (51.2% )</td>
</tr>
<tr>
<td>Very satisfied</td>
<td>18 (29.5% )</td>
<td>43 (70.5% )</td>
<td>61 (37.7% )</td>
</tr>
</tbody>
</table>

Table legend:* 0 to 100 with 100 as extreme

Missed days of work and reporting pain to the supervisor.

This same cohort of RTTs was asked about the amount of time that they had taken away from work due to their work-related musculoskeletal injuries. Almost half of RTT respondents (47.1%) reported that they took time off from work due to their pain. An additional question was posed as to the number of days taken on average due to work-related pain and the majority took 1-3 days off due to some type of work related pain. 58.3% of RTTs reported that they did not take time off work due to their pain. When considering those RTTs that did work in pain, 44.7% of them did report their pain to a supervisor. The complete listing of frequencies for the RTTs who had pain and responses to taking time away from work, is provided in Table 9.
Table 9. Radiation Therapists who have taken time off work due to pain or have reported pain to their supervisor.

<table>
<thead>
<tr>
<th>Did take time away from work</th>
<th>55 (41.7%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3 days</td>
<td>27 (20.5%)</td>
</tr>
<tr>
<td>4-5 days</td>
<td>6 (4.5%)</td>
</tr>
<tr>
<td>6-10 days</td>
<td>2 (1.5%)</td>
</tr>
<tr>
<td>More than 10 days</td>
<td>20 (15.2%)</td>
</tr>
<tr>
<td>Did not take time away from work</td>
<td>77 (58.3%)</td>
</tr>
<tr>
<td>RTTs who reported pain to a supervisor</td>
<td>59 (44.7%)</td>
</tr>
</tbody>
</table>

Summary

81.5% of RTTs that responded to this survey reported pain during work. This self-reported work pain was anatomically located for the majority of RTTs in the low back, neck, and shoulder areas. There were high levels of job satisfaction among this cohort however, the respondents felt that the job was both physically and mentally demanding. Those RTTs who are novices and those with 16-20 years of experience reported the most frequent pain per age range, however many did not take off time from work for this reason. This reporting of work-related musculoskeletal pain was made by the majority of RTTs to their supervisor which may or may not have been reported to occupational health and safety.
Chapter 3: Discussion

This survey research was designed to fill a void in the profession of the Radiation Therapist (RTT) that heretofore was speculated to be plagued by work-related musculoskeletal disorders (WRMSD). To that end, the data from this survey research is compare to the literature that has been published in other occupations, to provided added context. It is also important to underscore that this work only address a small portion of the multivariate interaction theory model, proposed by Kumar. The model is again provided however this discussion is relegated to only the portion of the model highlighted in Figure 6.

Figure 6. Kumar’s model of multivariate interaction theory with subgroups highlighted in orange.
Demographics and Self-reported pain.

The level of pain that was reported by the RTTs in this study, is worth comparing to a similar survey collected on a cohort of sonographers and vascular technologists. RTTs work in a separate area of the hospital however the level of patient engagement and time spent with a patient is worthy of comparison. It is important to note that RTTs and sonographers/vascular technologists are not completely matched in the way they move their bodies while performing their patient care duties. However, both RTTs and sonographers/vascular technologist are considered a female dominate medical profession and perform procedures on multiple patients a day. They are alike in the repetitive nature in which they perform their main job duties. Since pain can be linked with these repetitive motions, it is assumed that these two could be compared in the presence of pain while working. In the present study, RTTs’ pain was rated at 81.5%, whereas 90% of a cohort of sonographers reportedly were working in pain.21 The sonographers in the Evans et al. study had self-reported pain more targeted to the wrists, hands, and shoulders. On the contrary, the present study of RTTs’ self-reported pain was located more in the anatomical regions of the low back, shoulder, and neck of which match up quite well with those reported by the RTs in the Kumar study looking at non-specifically specialized RTs.12

Higher level evidence has been published on RTs, more recently, as part of a large study of hospital workers who are engaged in patient handling duties. In a study by Pompeii et al., a large cohort of workers information was retrospectively investigated for injury claims.22 Examining the data from the RTs in this study, 95 claims were filed over the time period studied and associated with three major work tasks including transporting...
patients (pushing or pulling) from one location in the hospital to another, lifting a patient, and assisting a patient to the bathroom or bed based on claims data from RTs. Additionally RTs were the third most likely group of workers to report injuries by pulling patients up in bed, compared to the present study. These are all similar patient handling responsibilities that RTTs in the present study must do in order to safely assist patients and the high level of reported pain at 81.5% among respondents.

The top three major anatomical areas of concern among those who reported pain in the present study include pain in the: low back (78%), neck (76%), and shoulders (73%). There are several other professions in healthcare that have reported pain data that are comparable to these anatomical areas causing the most pain in RTTs. RTTs in this study specified that a majority of their pain was focused on the lower back region. Other healthcare occupations that have reported incidence for low back pain are Physical Therapists (PT), Occupational Therapists (OT), and nurses. A study completed by Darragh et al. reported that low back injury were the highest reported injury in PT and OT respondents. Much like RTTs, PTs and OTs are often assisting patients from wheelchairs to tables for treatments. Lifting patients with limited mobility is a genuine concern and also was reported by RTs in the Kumar et al. study.

A multitude of studies have also been completed that analyze nurse’s workplace injuries. While the job duties of nurses differ from RTTs, RNs have been found to have similar amounts of low back pain that can be associated to the same anatomical areas of most of the RTTs pain. This low back pain experienced by both occupations can be related back to patient handling and transferring in order to ensure a safe and comfortable environment for these patients. A former study analyzed low back pain specific to
RTTs. This dated study had a similar level of RTTs reporting low back pain, but did not explore pain in any other anatomical areas.

Neck pain was also targeted by Kumar et al. as the second most prevalent area that RTs experienced pain as was also seen in the present study’s cohort of RTTs. As computer screens and workstations become a more integral part of the new technologies for RTTs, this prevalence of neck pain should be monitored as bad posture can attribute to neck pain. RTTs spend a substantial amount of time sitting at a work station reviewing charts and medical records as well as operating the controls to the linear accelerator or CT scanner while monitoring the patients on cameras that may be at less than ideal angles for viewing. Also of note, high levels of psychosocial stresses are seen in the present study’s RTTs with a mental demand of 80.7/100 and the perception of a hurried or rushed pace of 73.5/100 in those that reported also working in pain. This mental concentration and stress can lead to further physical risks due to forward head posture that increases the muscle activity and exacerbation of neck pain because of work done on the computer console under these job demands.

The third most prevalent site of musculoskeletal pain according to the present study was reported in the shoulder. Pain in this anatomical site was just slightly less reported than neck pain in this cohort of RTTs. According to a study performed on occupational shoulder pain in the general workforce by Linaker et al. shoulder pain can sometimes present from referred pain from the neck. They found that the high rate of occurrence of these two anatomical areas had proven association. With RTT shoulder pain occurring in 73% of respondents working in pain, it aligns with existing evidence on common shoulder movements that have caused strains and pain including: overhead
working, heavy lifting, forceful work, and working in awkward positions. Because of the height of the radiation therapy couch that has to be raised for a RTT to perform their job duties, repetitive work with hands positioned above the shoulders is required in order to physically align a patient raised in the air at the treatment isocenter. The other movements found in this study that are listed above are also other movements performed by RTTs that also would make sense for contributing to the high levels of reported shoulder pain. Heavy lifting could either entail that of transferring or assisting patients to the treatment couch or lifting immobilization equipment necessary for patients’ set ups for treatment.

Another consideration for the elevated occurrence of WRMSDs is the types of patients that these RTTs are expected to handle on a daily basis. Elderly patients (43.7%) followed by heavy or obese patients (26.1%) were the most frequent two patient types that were considered to be the most physically demanding patients to manipulate on the treatment table. These patients are equally difficult to transfer to the therapy couch from beds or from wheelchairs. With these types of patients, mobility is an issue and a great deal of assistance is required in order to accomplish a safe transfer without injury to the patient. According to the National Cancer Institute, the average age of cancer diagnosis is 66. Given that many patients receiving daily treatments are elderly as well as having an oncologic condition, extreme care must be taken in order to transfer these patients safely onto the treatment table. Bony metastasis is often treated with radiation therapy in order to provide pain relief and prolong quality of life. These metastatic patients are then generally also elderly based on the typical age of cancer diagnosis. They are at risk for fractures and are often in a great amount of pain requiring vigilant assistance. Based
on the present study and others with similar occupational duties, WRMSDs can be associated with patient transfer responsibilities as well as the increasing number of patients having limited mobility.\textsuperscript{12,23} The second type of patient identified as being physically demanding are obese patients. According to the World Health Organization (WHO 2018), obesity is one of the most prevalent health problems worldwide.\textsuperscript{31} With an increase in this type of patient, best practices in handling these obese patients must be kept in mind to make decisions that are safe for the healthcare provider, safe for the patient, and encourages patient participation and independence.\textsuperscript{32} Spinal loading, which is the maximum amount of force on the spine, was tested on a variety of patient transfer and repositioning techniques and lower back injury.\textsuperscript{14} No matter the technique, a significant risk of low back disorder was associated with these lifting tasks.\textsuperscript{14} There is reason to assume that this amount of weight is exceeded multiple times daily for the respondents in the present study having to assist these obese patients. A particular instance that aligns to the reported incidence of shoulder pain as it pertains to the obese patient population would be reaching to make an adjustment on an obese patient that is positioned on a table above the RTTs shoulder height. This could be a significant contributing factor to the high level of shoulder pain reported by this cohort of RTTs as is described by Linaker et al. for body movements such as heavy lifting and working overhead further exacerbated by combining these two damaging movements at the same time.\textsuperscript{28} See Fig 7 as an example.
Physical & Mental Demand.

It is important to consider what types of factors are contributing to the increased levels of pain that RTTs are experiencing in the workplace. Some factors studied included the pace of work and the frequency of patients that were perceived as physically challenging. This physical workload of combined pace and difficulty of patients is comparable to other studies done that have looked at a high pace of work like the current study. Most RTTs in the current study that also said they were in pain had also stated that they had performed more than 19 radiation therapy treatments per day with the average case lasting 11-15 minutes in time. This high work pace atmosphere where there is a quick turnover of patients has generated a higher physical stress on the body as compare to studies by Tinubu et al. in a study on nurses that found caring for excessive amounts of patients each day was a risk factor in WRMSDs. Lorusso et al. examined
RTs in a predominately male workforce in Italy showing that high physical workloads generated a higher prevalence on WRMSDs as well.\textsuperscript{33}

In addition to the physical demands of the job, there are certain psychosocial demands that come along with the profession that are important to discuss due to the risk of these factors playing into the physical wellness and exacerbation and acceleration of injuries. The perception of mental demand among those who reported pain was high (80.4/100) and the perception of a hurried or rushed pace was also high (71.9/100). These factors have been studied to assess their impact on WRMSDs. Bongers et al. studied how different work stressors effected the occurrence of WRMSDs. This study was a literature review specifically focusing on how psychosocial factors related to the pain experienced in anatomical sites of the back, neck and shoulder as were the main sites of pain in the present study.\textsuperscript{34} Some factors reviewed include working at a hurried pace and the mental demands of the job which paralleled with the present study. In particular, a positive correlation was found between levels of neck pain and hurried pace of work.\textsuperscript{34} Lorusso et al. also related these high job demands with neck and shoulder pain.\textsuperscript{33} With neck pain being reported in 76\% of respondents in the current study, there is reason to believe that these high paced atmospheres contribute to the amount of neck pain reported in the present study.

One interesting finding of the current study was that RTTs overall reported high amounts of job satisfaction (89\% reporting somewhat or very satisfied) even though 81.5\% were working with pain. Interestingly, when these results were broken down into categories of pain and no pain, those that reported low job satisfaction (not at all satisfied or not very satisfied) were predominately all in the grouping of RTTs that stated they
were working in pain. Even though those reporting low job satisfaction were few, there was a high percentage of those who reported working in pain which aligns with research findings by others.\textsuperscript{34,35} Some other factors of job stress in the current study include the perception of a hurried work pace (71.9/100), and physical (71.5/100) and mental (80.4/100) demand were also considered elevated by respondents of the present study even though the job satisfaction was considered high. The overall amount of high job satisfaction is contrary to some studies that have found that low job satisfaction or high work stress equates to more frequent WRMSDs.\textsuperscript{34,35} This is also reflective of the number of respondents who have worked for more than 21 years that have had longevity in this career, despite their self-reported pain. The current group of respondents were not longitudinally tracked, so it is impossible to determine when in their career that an acute workplace injury might have started.

It is important to consider the influence of the mental work demands on the incidence WRMSDs. This is a difficult association to make given the intermingling of both the physical and mental demands of the job and how these might increase the risk for a WRMSD. In an effort to isolate WRMSDs to a micro-level, Barbe et al. studied a focus of what is driving these WRMSDs and how prevention and early intervention are critical in order to slow the rate that WRMSDs are occurring.\textsuperscript{36} The overuse and repetitive injuries can cause a chronic inflammatory response causing fibrosis, tissue changes, and may lead to illness, depression, and anxiety. If the injured body part is rested and chronic inflammation does not occur, the tissue is believed to be allowed to repair and these physical and mental ailments can be prevented.\textsuperscript{36}

\textit{Implications of Pain while Working}
An interesting perspective to consider is the interplay between job stress, satisfaction, and time taken off work due to WRMSDs. Specifically looking at time taken away from work due to low back pain, Hoogendoorn et al. studied a cohort of employees to see different physical and psychosocial factors that occurred and then measured sick leave of greater than 3 days. The baseline for this cohort was taking no more than 3 sick days and then added data was recorded over the next three years. The investigators recorded video data for physical aspects, survey data for psychosocial aspects, and company records for sick leave data. The survey concluded that those being observed who took more than 3 sick days was related to the physicality of flexion and rotation of the trunk and lifting as well as mental factors related to low job satisfaction. The present study did not get detailed reporting on the reasons for the use of sick leave, as it relates to anatomical site. It is worth noting that 58.3% of those working in pain in the current study did not take time away from work in order to get physical rest from their work-related injury. For those RTTs who did take time away from work, 20.5% took between 1-3 days.

Another factor studied in the Hoogendoorn et al. study was that of low social support from peers or supervisors that had a correlative effect on sick leave taken. Reporting pain to supervisors was part of the present study and 44.7% of those experiencing pain reported it to their supervisors. It could be hypothesized that the level of reporting could be highly dependent on relationship of the employee with the supervisor. As RTTs have high job satisfaction, their supervisor support may or may not play into their degree that they responded to this question.
WRMSDs have been seen to increase costs to employers through paid sick time, low productivity, worker’s compensation claims due to injuries, temporary staffing, backfilling, and overtime. Another question to consider is what types of implications this means for those currently working with or without injuries. Short staffing adds both mental and physical stress loads as those still working are still expected to accomplish the same amount of work. This could lead to new or a continued exacerbation of these injuries. Mandatory overtime had been linked to more musculoskeletal problems in a longitudinal study by Trinkoff et al. An added area that requires attention is the phenomenon of *presenteeism*, which describes the employee working in pain or reporting to work but contributing less to the overall lab’s productivity and quality of work. Presenteeism has been studied in other professions, and it has the potential to cause deleterious productivity or quality of work. With RTTs reporting a high level of pain, but not reporting their pain or taking time off work to mitigate their pain, this could leave detrimental consequences. Fellow staff members would have to accommodate for the lack of work a coworker is achieving. This could lead to an exacerbation of the workload and potentially other injuries in order to achieve the same amount of work with less staffing actively engaged in the work. This also could lead to unsafe conditions for patients when the quality of work is diminished as a result of low presenteeism.
Chapter 4. Conclusion

Radiation Therapists (RTTs) may be at a high risk for developing painful musculoskeletal injuries. This work was only able to explore a small portion of the multivariate interaction theory, so many factors described by Kumar remain to be examined. It has been shown that certain occupational movements and psychosocial factors have demonstrated a link to WRMSD, based on published research and supported by this cohort. This study was the first of its kind to study RTTs specifically and the results can serve as a starting point for further research in the prevention of WRMSDs among RTTs. There is an overall high amount of RTTs working in pain at 81.5% and the top three anatomical areas of pain include the lower back, neck and shoulders. By identifying the areas of the body where most of pain was experienced in this study, targeted prevention can be better detailed and effective. The most commonly encountered patient types that were physically demanding were elderly patients and obese patients. In assessed psychosocial aspects there was an increase in the perception of a hurried or rushed pace in those reporting they experienced pain versus not experiencing pain. RTTs in this study also experienced a high level of mental demand regardless of the presence of pain. The majority of those reporting pain did not take time off work because of this pain.

Future Directions

Future research should also address those portions of the multivariate interaction theory that remain be examined with RTTs. Additionally it would be important to monitor what areas of the body RTTs experience painful symptoms due to rapid advances in technology that may change anatomical areas where RTTs may experience pain.
Support from leadership is not addressed in the multivariate interaction theory therefore this is an additional macro-level influence that needs to be explored. It could be hypothesized that hospital leadership could support employees and thereby mediate these symptoms by establishing a safe patient handling culture and a high level of patient care. This leadership fostered culture has the potential benefit of reducing costs in both worker compensation claims and reduced productivity, due to employee discomfort.

**Limitations**

For data collection purposes, the low response rate has the potential to reduce the external validity. Among these respondents, it was possible that those who were currently suffering from musculoskeletal symptoms were more likely to respond. Recall bias may affect data, but every effort was made by framing the questions such that recall was limited to just those symptoms occurring in the past year. Another point of contention is that musculoskeletal symptoms are multifactorial in nature. While movements on the job could be major contributing factors to musculoskeletal pain, it is noteworthy that a person’s previous exposure to injury and out of work activities could contribute to their symptoms in various degrees. Therefore it is very difficult to isolate work-related exposure from the RTTs entire life experience.

Given that this is a survey of a large cohort of RTT respondents, the lack of randomization would cast this research as experimental. The inherent threats to internal and external validity are limitations to this pre-experimental research.
Bibliography


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