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Poor Ergonomics and Neck Flexion: Evaluating the Prevalence of Musculoskeletal Neck Pain in Dental Hygiene Students

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ABSTRACT

Proper ergonomics are important to minimize operator fatigue and discomfort. Poor ergonomics has been proven to be the leading factor in developing musculoskeletal disorders. Musculoskeletal disorders are one of the most important occupational health issues. Studies have been conducted in the past to investigate dental professionals and the risk for developing work-related musculoskeletal disorders and found this occupational group at higher risk. However, research on dental hygiene students is lacking. The purpose of this study was to investigate the prevalence of dental hygiene students being affected by musculoskeletal pain in the neck region in early dental hygiene education and if musculoskeletal pain was associated with the participants degrees of forward neck flexion during manual scaling procedures. A total of 50 practice trials were conducted using a Goniometer Pro (G-Pro) application on an iPhone 8 plus to measure neck flexion. Twenty-four dental hygiene students consented to participate in the observational study. Participants degree of neck flexion was measured with the G-Pro application 30 minutes into a manual scaling procedure in an already established educational setting and after

participation, a short form McGill Pain Questionnaire and an additional survey was handed out via paper to the participant. The results determined that all participants neck flexion exceeded the recommended $\leq 20°$ and half of the participants expressed having cervical pain or problems.

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CHAPTER I: INTRODUCTION

Introduction:

Musculoskeletal disorders are one of the most important occupational health issues in health care workers.[1] This disorder is identified as injuries to the human body support system such as the ligaments, tendons, muscles, nerves, blood vessels, bones, and joints.[1] Poor ergonomics is one of the leading factors to developing musculoskeletal disorders. This is especially common in experienced dental hygienists but has also been reported in dental hygiene students.[2] When health care workers develop this, it is referred to as work related musculoskeletal disorders (WMSDs). Awkward postures, precision work, and repetitive low-level force exertion have been identified as major risk factors for the development of work-related musculoskeletal disorders.[2]

The physical demands for the upper extremities in dental hygiene create an increased risk for developing WMSDs in the neck and shoulders. Poor ergonomics such as excessive neck flexion, constrained working postures, excessive static and peak loading of the upper trapezius and the forearm extensor muscles all play a role in developing WMSDs.[2] Early retirements within the field of dental hygiene have been said to be a result of WMSDs.[2] This in turn, negatively effects productivity and job satisfaction for people in the dental hygiene field. Dental hygienists may also consider an alternate career route because of this disorder and the pain that WMSDs causes. Dental professionals are at an increased risk of developing musculoskeletal disorders with a 64%-93% prevalence rate.[3]

Statement of the Problem:

Do musculoskeletal disorders appear in dental hygiene students early in their education? Is the students' lack of control to maintain proper operator positioning effecting their neck flexion during patient care? When dental hygiene students fail to implement and maintain proper ergonomic operator positioning and exceeding 20° of neck flexion, will it contribute to musculoskeletal disorders early in education?

Significance of the Problem:

Musculoskeletal disorders are extremely common among dental professionals. Work related musculoskeletal disorder, WMSDs, is defined as a condition where upon working on tasks, the nerves, tendons, muscles, and supporting structures are affected. The condition of WMSDs can be slight and recurrent or can be severe and incapacitating. Early symptoms look like swelling, pain, tenderness, numbness, tingling, and loss of strength in the structures that are affected. Of all health care professionals, dental hygiene is more frequently reported to suffer from WMSDs. This disorder is the most common of all occupational health hazards.[4]

There are many risk factors that could be the cause of WMSDs. Unique factors among these dental professionals include a limited working field, static postures, unique movements, fine and repetitive movements or tasks. Work related musculoskeletal disorders have been specifically reported in the neck, shoulders, wrist, and lower back. In recent years, there has been supporting evidence that undergraduate dental hygiene students are experiencing musculoskeletal disorders early on, but there is still lack of research within the student population. The same factors affecting dental professionals with WMSDs have been the same factors affecting dental hygiene students in the neck, shoulder, wrist, and lower back.[5]

It is important to study and identify risk factors that are commonly causing musculoskeletal disorders amongst dental professionals, specifically looking at risk factors that can influence dental hygiene students in early education. The prevalence of this disorder has been more commonly reported with years of practicing in dental hygiene but the limited reported prevalence in dental hygiene students could be due to the lack of research with dental hygiene students.[1]

In a study by Werner RA, Franzblau A, Gell N et al., entitled the prevalence of upper extremity symptoms and disorders among dental and dental hygiene students, revealed that Michigan students experienced very few upper extremity musculoskeletal symptoms during their clinical training and education.[1] Contradictory, a pilot study done in Connecticut with dental hygiene students revealed that they experienced symptoms in the hand and arms early on in their training.[1] Ultimately, dental hygiene students are experiencing musculoskeletal disorder symptoms early in their education. Regions such as neck, back, shoulders, hand, wrists, and lower extremities have all been self-reported to exhibit pain and documented as areas to develop WMSDs. [1,5] The appearance of lower extremity pain is less significant than upper extremities, but it is still present.[1]

A study done by Hayes, et. al., included a questionnaire to dental professionals. The questionnaire consisted of a number of tick-box style questions and two short answer responses, covering demographic items, registration status, qualifications, current work habits, psychosocial factors, ergonomics education and musculoskeletal symptoms. To assist participants in answering questions focusing on musculoskeletal symptoms, an anatomical diagram was used to clearly identify body regions. Participants in this study reported that they took protective measures against WMSDs. The participants who utilized loupes were less likely to suffer from

WMSDs. It has been suggested that the use of dental loupes is beneficial to dental providers. They help create better posture, and the research states that they are beneficial to reduce WMSDs pain.[3]

Another protective measure that was reported was ergonomic education. Those who received ergonomic education were less likely to have WMSDs pain. These two factors, wearing loupes and ergonomic education, can easily be implemented into dental hygiene student education to help prevent WMSDs.[3] Ergonomics can be explained as the science of fitting both the physical and psychosocial work and working environment to the individual. Physical work can include lighting, temperature, noise, equipment, and work station design whereas psychosocial is the interpersonal relations and attributes.[4]

An ergonomic intervention should become more popular during dental hygiene education throughout the curriculum. Implementation of an ergonomic process guide can be used in training. Turcotte-Michalak, author of "Controlling dental hygiene work-related musculoskeletal disorders: The ergonomic process", states that a plan should be designed for training and education for those who are at risk for WMSDs. In turn, this would increase awareness and promote early intervention. Working with a plan that consists of the ergonomic process can help identify risk factors for WMSDs and reduce or eliminate WMSDs early on. Simple tasks that Turcotte-Michalak mentioned in the report were to check for instrument sharpness, use of the cavitron ultrasonic, have the students listen to a guest speaker about the importance of ergonomics and poor body mechanics, or implement a stretching regime for everyday tasks.[4]

Operational Definitions:

Ergonomic: Design factors, as for the workplace, intended to maximize productivity by minimizing operator fatigue and discomfort.

Musculoskeletal Disorders: are injuries or pain in the human body support system such as the ligaments, tendons, muscles, nerves, blood vessels, bones, and joints.

Body Mechanics: The application of kinesiology to the use of proper body movement in daily activities, the prevention and correction of problems associated with posture, and the enhancement of coordination and endurance.

Biomechanics: The mechanics of a part or function of a living body.

Loupes: Small magnifying glass; typically, on protective eye wear for dental professionals.

Influencing factors: One that actively contributes to an accomplishment, result, or process.

Static Balance: Balance that occurs when a center of gravity of an object is on the axis of rotation and this allows the object to remain stationary.

Goniometer: An instrument used to measure angles.

Flexion: The action of bending a joint or limb in the body by flexors.

CHAPTER II: LITERATURE REVIEW

Introduction:

This review of literature is aimed to explore the major reported risk factors associated with musculoskeletal disorders, MSDs, in the dental hygiene profession and the major regions associated with pain. Also, determining the prevalence of tension neck syndrome, TNS, a more specific and common diagnosis. Ultimately, this literature review will be looking into the most contributed factors that are influential to MSDs, prevalence of MSDs, reported early pain associated, and determine early intervention of ergonomic techniques for dental hygiene students. Articles have been searched through PubMed database, ADHA website, the University of New Mexico's Health Sciences Library and Information Center with World Cat database, Science Direct and BioMed Central databases, and dental hygiene information has been searched through published textbooks.

Musculoskeletal Disorders Defined:

Musculoskeletal disorders, MSDs, are identified as injuries to the human body support system such as the ligaments, tendons, muscles, nerves, blood vessels, bones, and joints. This is often a result of cumulative trauma to these areas.[1,3] There are many risk factors influencing this disorder related to dental hygiene tasks. Static work postures, repetitive motions, and force exertions have all been identified to be important risk factors of potentially causing harm. With these, there are also factors such as limited working field and awkward postures.[2,7,5] These are all unique factors for musculoskeletal disorders among dental hygienists, however, there is a number one leading factor. That factor is, poor ergonomics.[2] Symptoms of this disorder will involve swelling, pain, tenderness, numbness, tingling, and loss of strength in the structures that are affected. The condition of MSDs can be slight and recurrent or can be severe and

incapacitating.[4] The symptoms related to this have been shown to be, but not limited to, a result of the static work postures and static muscle activity.[8]

Ergonomics Defined:

Ergonomics can be explained as the science of fitting both physical and psychosocial work and working environment to an individual. Physical work can include lighting, temperature, noise, equipment, and work station design where psychosocial is the interpersonal relations and attributes.[4,9] The goal of ergonomics is to develop a safe and comfortable working environment. This would then prevent health problems and improve productivity. When applied to dentistry, ergonomics seeks to reduce the cognitive and physical stress, prevent occupational diseases related to dentistry, and improve quality of comfort for the dental professional.[10,11]

There are few published studies evaluating dental hygiene students' perceptions on ergonomics and their experiences while practicing dental hygiene in relation to musculoskeletal disorders. In dentistry, it is a known factor that ergonomics is related to musculoskeletal disorders. A study by Garcia, P. et., al, where dental students were interviewed with several questions regarding ergonomics, results showed that 58.6% of these students believed that adopting ergonomic posture in school is important in limiting future problems, pain, or occupational diseases. This was demonstrated and also confirmed through the interview process. Of these students, 62.1%, believed in adopting changes but found it difficult due to the treatment they needed to provide for patients. Some of the main reasons reported for abandoning good ergonomics postures was, as 44.8% reported, due to their lack of attention, forgetfulness, and practice. Another reason for not practicing these good ergonomic postures was because of difficulty visualizing their operatory field for many procedures. This was found by 27.6% of the students.[11]

Work Related Musculoskeletal Disorders:

Physical demands of the upper extremities in dental hygiene creates an increased risk for developing work related musculoskeletal disorders, WMSDs.[2] This disorder is one of the most important and most common occupational health issues in health care workers.[1] Work related musculoskeletal disorders involves risk factors described as resulting from precision work, static postures, repetitive movements, awkward postures, and force exertions. Musculoskeletal disorders and WMSDs share similar definitions. In this case, work related is pertaining to dental hygiene.[7, 2,5,12]

Noh, H., and Roh, H., state in their study through the *Journal of Physical Therapy Science* that WMSDs in dental hygienists is also related to the work environment, texture of instruments, glove type, and maintaining and operating with heavy force equipment. Along with equipment and accessories of dental hygiene, working positioning of a dental hygienists is very crucial to WMSDs.[13] Retirement and career changes have been reported as a negative result from dental professionals affected by WMSDs.[2] Work related musculoskeletal disorders have been said to effect productivity and job satisfaction for dental professionals. An article posted in the *International Journal of Dental Hygiene* by Hayes et., al, has stated that dental professionals are at an increased risk of developing WMSDs at a 64%-93% prevalence rate.[3]

Regions Mostly Effected by Musculoskeletal Disorders:

Musculoskeletal Disorders can cause pain in the neck, shoulder, wrist, arm, hands, upper and lower back, hips, feet and knees.[1] The study by Noh, H., and Roh, H., also showed results that manual scaling and ultrasonic scaling showed no differences when at the 7 o'clock and 11 o'clock positions and both showed to be the most dangerous working positions. However, results from another study reported scaling caused more pain in the forearm extensors and higher loads

on the trapezius muscles. Ultrasonic scaling showed to have reduced that pain by 50% when compared to manual scaling. Inappropriate postures can also lead to increased body fatigue more quickly especially in a static posture position.[13]

A longitudinal study by Nicholas Warren from the University of Connecticut Health Center was conducted from 2002-2005 and tested five different occupational groups on musculoskeletal disorders. Of these groups, two out of the five groups included dental hygiene students and experienced dental hygienists. The results concluded that pain intensity in the neck and shoulder is primarily associated with the bending of the neck and twisting exposure factor. The neck bend and twist were found to be mostly related to the biomechanical exposures. Worst pain in the hand and or wrist is associated with the static grip and reach factor. In conclusion of this study, it was found that dental professionals, dental hygienists and dental hygiene students should be more aware of the biomechanical and psychosocial risk factors that appear to contribute to the high rates of musculoskeletal disorders. It is also important for this occupational group to understand these risks in their career.[14]

The major risk factor seems to be sustained exertion, awkward static postures in the upper extremities, and bending of the neck. Tension neck syndrome, TNS, can be of diagnosis from these risk factors. TNS involves painful neck spasms and trigger points that comes from a specific type of work loading common in dental hygiene.[15] TNS symptoms also include stiffness around the neck and limited movement, pain radiating down to the arms and between the shoulder blades, and palpable hardness in the neck.[16] It is important to understand a healthy degrees of neck flexion to prevent neck symptoms. The appropriate degrees of forward neck flexion should be $\leq 20°$.[17,18,19,20]

Akesson et., al produced a study using 51 female dental hygienists to assess their work load performing dental hygiene tasks. The prevalence of MSDs in a 12-month period reported an 82% with MSDs in the neck and 33% of the participants were diagnosed with TNS.[12] A study by Morse et., al included a physical examination of thirty minutes of intensive upper extremity evaluations performed by a physician specifically trained in musculoskeletal symptomatology. The participants were experienced dental hygienists who volunteered, 24% response rate, and also dental hygiene students from the three-different schools in Connecticut and dental assistants who are now in dental hygiene school. There was 57% of subjects that reported having neck pain and also had physical examination of abnormalities. Self-reported neck symptoms such as pain, aching, stiffness, spasm, inability to move head, burning, numbness, or tingling was reported in 37% of dental hygiene students. The experienced dental hygienists reported with 72.3% of having these symptoms. Of the 27 dental hygiene students who were investigated in the study 79% were found working with a bent neck often or very often.[15]

A recent review by Hayes, et. al published in the *Journal of Dental Hygiene* showed that more than half of dental hygiene students have reported musculoskeletal disorders in any region of their body. Across a three-year span, the study consisted of dental hygiene students in an Australian University. The first year had 50 students, second had 51, and third had 41 students. All of the students who had reported stress about dental hygiene school had reported pain in all of the most noted regions. For example, the neck was the most commonly reported region to have pain. The prevalence of neck pain increased from a 66% to a 68.3% from 2008 to 2010. Lower back pain increased from 62% to 68.3%. Shoulder pain was also increased over the three years from 44% to 46.3%. Upper back increased from 42% to 43.9% and wrists and hands increased from 34% to 43.9%. The results could be because of the increased time in clinical

settings as dental hygiene students move up into the program, but it is also an indicator of possible prevalence for MSDs upon graduation and in experienced dental hygienists through their career. The same regions associated with pain in experienced dental hygienists are the same areas that have been reportedly associated with pain in dental hygiene students. [5]

Measuring Neck Flexion:

An article published in 2017 through *The Spine Journal* titled, "A new iPhone application for measuring active craniocervical range of motion in patients with non-specific neck pain: a reliability and validity study", conducted a cross-sectional study measuring flexion in participants with nonspecific neck pain. Active craniocervical ROM (ACCROM) was measured by two blind examiners using a UG, universal goniometer, and an iPhone 7 app. The aim of this study was to determine the validity of the iPhone 7 app which in this case was the G-Pro that works like a digital gravity-based inclinometer and computes the angle between two adjacent segments. The participants were asked to sit upright in a chair while the examiners recorded ACCROM in the order flexion, extension, lateral flexion, and rotation. The results concluded that the G-pro app was excellent in validity and reliability to the UG instrument. The differences were not statistically significant, and the app is available at any time which is shown to be an advantage.[21]

Loupes and Posture:

Dental hygiene work requires hand-eye coordination, as well as sitting for prolonged periods of time. Dental hygienists also have repetitive scaling motions for the removal of tartar from the teeth. This involves the dominant and non-dominant hands for holding the instruments. Dental hygienists and a relationship with WMSDs are well documented in literature. Most commonly cited pain is neck pain by dental hygienists. This pain in the neck is a natural

consequence from neck flexion when sustained for longer time periods. The nature of dental work forces many to flex forward with their neck. Dental hygiene loupes are an intervention to improve clarity while working and decrease the neck flexion while working. Loupes are magnification lenses that allow the dental hygienists to magnify their working area without putting neck flexion and stress on themselves. Loupes are suggested to improve the posture for the dental hygienists to help with the neck flexion and also help with shoulder protraction. Hygienists are also experiencing pain in their shoulders from "hunching over" to see their working area if not utilizing dental loupes. With dental loupes, these problems have been shown to decrease and help halt anymore musculoskeletal problems from arising.[22]

An article published in the *European Journal of Dental Education* by Garcia et., al, has suggested that as a practical implementation, dental hygiene students should begin pre-clinical work with the use of magnification loupes. Considering how important vision is for dental hygiene, using magnified dental loupes to help with posture and increase visual clarity in the working area, these should be used as an intervention beginning in education.[11]

Although dental loupes are found to reduce poor posture and decrease pain, they must be fitted correctly to be used in the most beneficial way. Valachi, B., who is a physical therapist and a dental ergonomic consultant published "Neck health: the three ergonomic criteria for loupes selection" and discussed how to properly choose dental loupes. The three variables to look at are the working distance, declination angle, and frame size. The working distance is from the operator's eyes to the work area. This distance should be measured with a patient in the chair and the patients mouth at elbow height. The operator should establish a treatment position in three different areas around the chair.[18] This will measure optimal working distance from 14-20 inches but depending on operator size, the working distance can be less than 14 or up to 22 inches.[18,16]

Valachi says most commonly observed in manufacturing of dental loupes is that the working distance is measured too short and causing excessive neck flexion. It is also important to have the declination angle steep enough to allow clarity into the working field without excessive neck flexion and also that the bigger the frame size that sits on the cheek allows for the microscopes to be placed farther down thus resulting in a better declination angle.[18]

Students Experiencing Musculoskeletal Disorders:

As much of the literature has said, dental work can cause dental hygiene students and dental hygienists to be in a fixed posture for prolonged periods of time. Posture has been defined or explained as reflecting the position that a person maintains in space. This in turn, affects the body's bone, muscle, and skeletal system, according to a static balance. Maintaining good posture is such a crucial element when going through dental hygiene school. Good posture will lower the body's energy expenditure, improve organ function, and protect against disturbances to the body that might cover up current occupational hazards.[10]

A study conducted by Garbin, et, al showed that dental students were not adequately utilizing good posture during clinical practice. Of the students in the study, 48% reported pain in their lower limbs and 81% reported pain in their neck and back regions. The study was also testing the knowledge that dental students had in regard to ergonomics and good posture. More than half displayed exceptional results in the understanding of good posture and ergonomics, but there was 40.6% who expressed an 'unsatisfactory' level of knowledge. A theory was identified that this could be due to a gap between theoretical definition and clinical application with adequate working environments.[10]

Computers and Musculoskeletal Disorders:

Musculoskeletal disorders have been expressed through the work with computers in today's society. Neck pain and upper extremity pain have become more common with results showing more of a relationship with computer work. A recent study cited by Waersted et., al, through *BMC Medical* conducted a study with 100 bank workers and their use of computers. They found that those who did have more extensive computer work resulted in more shoulder, neck, wrist, and elbow pain. Another community-based control study showed significant association with shoulder and neck pain within female workers. Diagnosis from the study expressed that 58% were affected and had tension neck syndrome, TNS, which were working on the computer for four hours or more per day. TNS is a more specific diagnosis specified in the neck region.[15,23] Several studies have found relationships with low or moderate work using key board evaluations. This is supported by a study that had found more trigger points and pain provoked by neck sideways flexion in subjects performing data entry work compared with subjects doing data dialogue work with both groups using the key board. The amount of TNS when working with computers is typically due because of the workstation layout and technique of computer work.[23]

Summary:

It has been shown through literature that there is a high prevalence rate of WMSDs for dental professionals. The highest and most common region affected by MSDs is the neck due to neck flexion past the healthy range of $\leq 20°$. Next would be the shoulders and lower back. Dentists and dental hygienists have reported signs and symptoms of MSDs and more specifically WMSDs and TNS with symptoms such as neck spasms, tenderness, and swelling. In the literature that has studied dental hygiene students, students reported the same symptoms in dental

hygiene school. Rates of MSDs in dental hygiene students are lower than that of experienced dental hygienists but also shows that during their career MSDs can increase.

Many dental hygiene students displayed a lack of knowledge of proper ergonomics in dental hygiene school and during patient care. While others expressed knowledge but confessed the failure of following correct positioning and ergonomics during patient care due to poor visualization. Poor ergonomics is one of the major contributing factors to MSDs and pain reported by dental professionals. It is important to incorporate correct ergonomics during education; which includes correct positioning and utilizing dental loupes. Dental loupes have decreased neck flexion and increased clarity. New technology has allowed researches to measure neck flexion in dental hygiene students utilizing an iPhone app and results showed reliability towards the app when measuring neck flexion. Another factor to remember, is that students are now utilizing computers more often. Literature has shown those who work with computers daily have an increased risk for MSDs. Because dental hygiene students are using computers more, there can be some increased risks of MSDs early in their education. For these reasons, ergonomics and the importance of it for dental hygiene students' needs to be present in early education.

CHAPTER III: METHODS AND MATERIALS

Introduction:

This research focused on studying poor ergonomics in dental hygiene students. Previous studies have examined musculoskeletal disorders among experienced dental hygienists and dentists, but very little literature focuses on the musculoskeletal disorders in dental hygiene students. The aim of this study was to evaluate dental hygiene students on the degrees of neck flexion when performing in a clinical setting by utilizing the Goniometer pro, G-Pro, application with the iPhone 8 plus. The present app for the iPhone uses a built-in accelerometer sensor and digital display to measure angles. Prior to beginning the clinical study, there were trials conducted to test the researchers (JS) reliability with the G-Pro application to measure neck flexion.

An evaluation assessment based on Branson's et., al, Posture Assessment Instrument (PAI) consisted of an acceptable, compromised, or harmful scale of neck flexion to categorize the degrees of flexion for each participant. The participants self-reported any pain using the short form McGill Pain Questionnaire provided at the end of the study via paper handout and an additional hand out was given for the participants to answer two questions. The desired outcome was to discover the prevalence of dental hygiene students being affected by musculoskeletal pain in the neck region in early education and if it shows association with their degrees of forward neck flexion.

Hypothesis:

Musculoskeletal disorders appear in dental hygiene students early in their clinical education. Dental hygiene student's failure to implement and maintain proper ergonomic

operator positioning, specifically neck flexion in excess of 20°, during manual scaling will contribute to neck pain early in education.

Sample Description:

The target population for this research includes second year dental hygiene students. A convenience sample of a maximum of 24 dental hygiene students from the University of New Mexico were selected. There were variations in age groups and gender.

Research Design:

A minimum of 30 trials were projected to test the researchers (JS) reliability using the G-Pro application. Informed consent was sent via email to Patricia Siegel, an occupational therapist (OT) and Assistant Professor at the University of New Mexico's School of Medicine to be passed to OT students of UNM. The OT students were asked to participate in the trial sessions. The consents were returned to Patricia and me then kept in a secure locked file. Patricia was alongside observing me while conducting the trial sessions using the G-Pro app to practice taking the measurements of neck flexion and then compared the G-Pro measurement with a standard goniometer. Below in Figure 1 shows the digital display of the Goniometer application to measure angles.

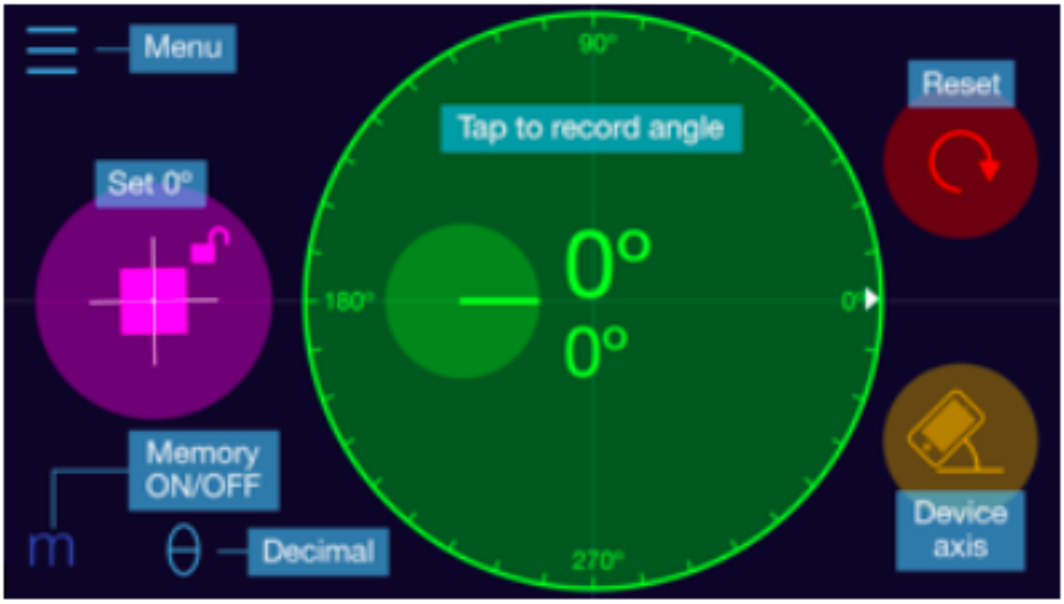

Figure 1: Digital display of G-pro application.

Second, informed consent was attached in the recruitment email sent to the perspective participants from UNM's dental hygiene program. The students were instructed to print out the consent form and those who desired to participate turned in the hard copy to myself and the principal investigator of this study kept them in a secure locked file. Informed consent was garnered from participants as a condition of enrollment in the study and participants were then assigned a study number. This research was conducted in an established dental hygiene educational setting that involved normal clinical dental hygiene education.

Utilizing the G-Pro app with the iPhone 8 plus, the participants were measured by aligning the phone over the external auditory meatus, aligned to the commissure of the lip on the right side of the persons face to determine the degrees of neck flexion. The measurement of neck flexion was gathered 30 minutes into a manual scaling procedure. Shown below in Figure 2 is the alignment from the external auditory meatus to the commissure of the lip. The center of the

iPhone was placed at the external auditory meatus at the test position, parallel or 0°. The phone was kept centered over the external auditory meatus and the moving arm, in this case present on the phone, would follow the flexion of the participants. Figure 2 also shows how degrees of neck flexion was gathered with participants when in an educational clinic setting thus wearing personal protective equipment, PPE.

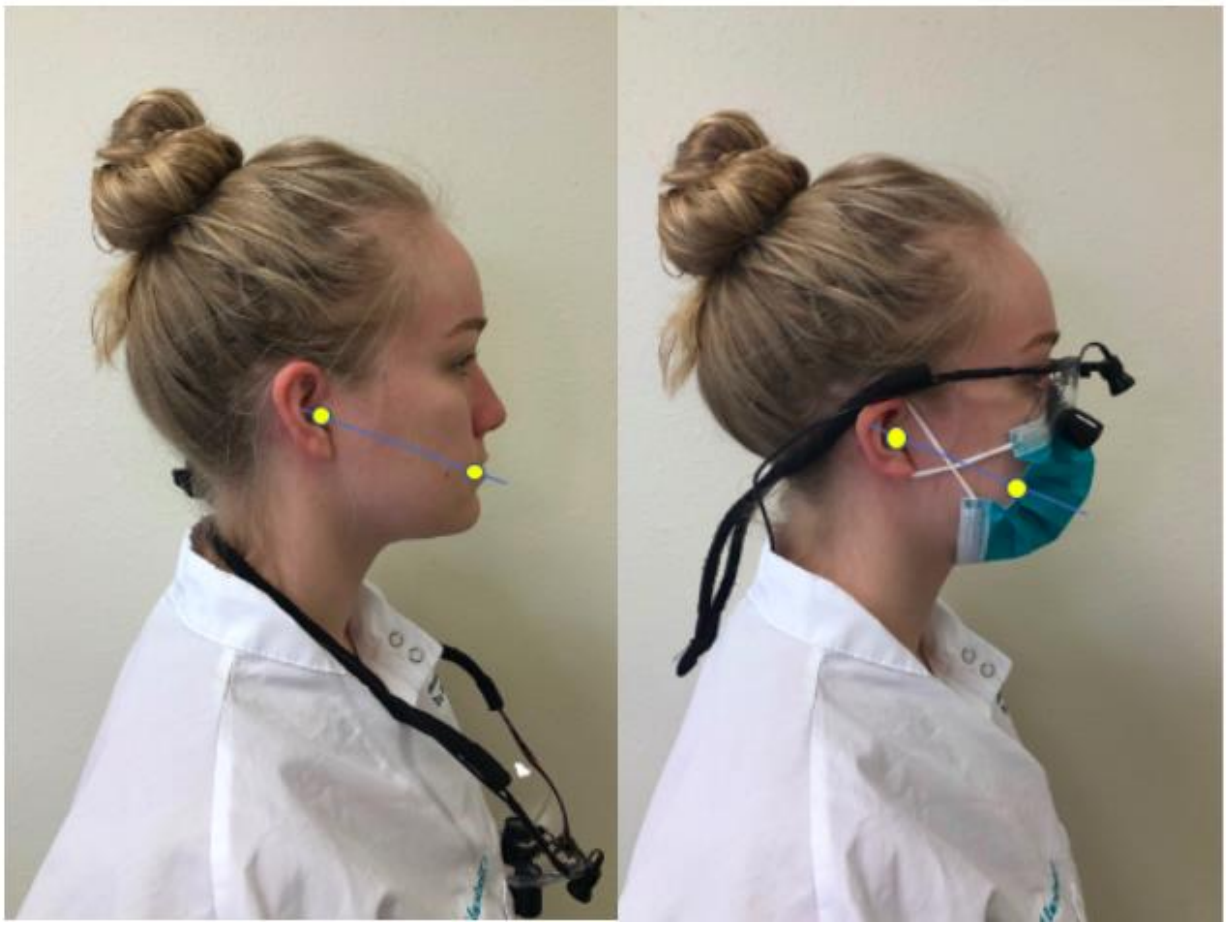

Figure 2: Measure points without and with mask.

The participants involvement in the study was no more than 30 minutes over a 5-week period. Participants were selected and measured during any time in the study period and the

criteria for selection was a manual scaling procedure. The study period began following approval of the University of New Mexico's Human Subject Review Committee and closed once all participants were measured, the McGill Pain Questionnaire was completed, and the additional questions answered. Participation was voluntary, and subjects had the choice to dis-enroll at any time.

Literature has continued to show that excessive neck flexion leads to pain in the neck and is to be one of the most common areas to exhibit musculoskeletal pain in dental professionals. Upon completion of a participant's clinical study with the G-Pro application to measure neck flexion, they obtained the short form McGill Pain Questionnaire via paper handout. This included a full body pain diagram that participants were instructed to mark on the diagram where they had any pain or problems. There were columns that the participants indicated the level of pain as either mild, moderate, or severe for the fifteen different pain associated words; if the words did not apply they were to be left blank. In addition to the short form McGill Pain Questionnaire the students were asked to answer a few additional questions as Yes or No. The questions were; Do you wear dental loupes when performing manual scaling during patient care? Have you had an injury to your head, shoulders, or neck regions prior to dental hygiene school?

Data Collection and Analysis:

All measurements of the participants' neck flexion were collected from a clinical established dental hygiene educational setting during the study period. The measurement of neck flexion gathered on each participant was captured through the G-pro app by tapping on the mobile devices screen when the iPhone 8 plus was at the external auditory meatus and the correct phone axis adjusted to the test position was established and aligned with the commissure of the

lip. Twelve readings can only be stored in the application at one time and therefore the data was transferred to a Microsoft Excel spreadsheet with the participants associated study number.

The criteria for the evaluation assessment of neck flexion included a healthy range (1) at $\leq 20°$, a compromised range (2) at $>20°$ and $\leq 45°$, and the harmful range (3) at $>45°$ based off of Branson et al.'s PAI. The participants data for neck flexion was grouped into one of the above categories and transferred to the Microsoft excel spreadsheet. The data from the short form McGill Pain Questionnaire was collected from the paper handout and each pain associated variables from the form was then transferred to the Microsoft Excel spreadsheet with the level of pain selected, if applicable. Answers to the additional questions was then transferred to the Microsoft excel spreadsheet. Body regions that were outlined on the McGill Pain Questionnaire and used to collect and categorize data for areas of pain or problems is shown below in Figure 3.

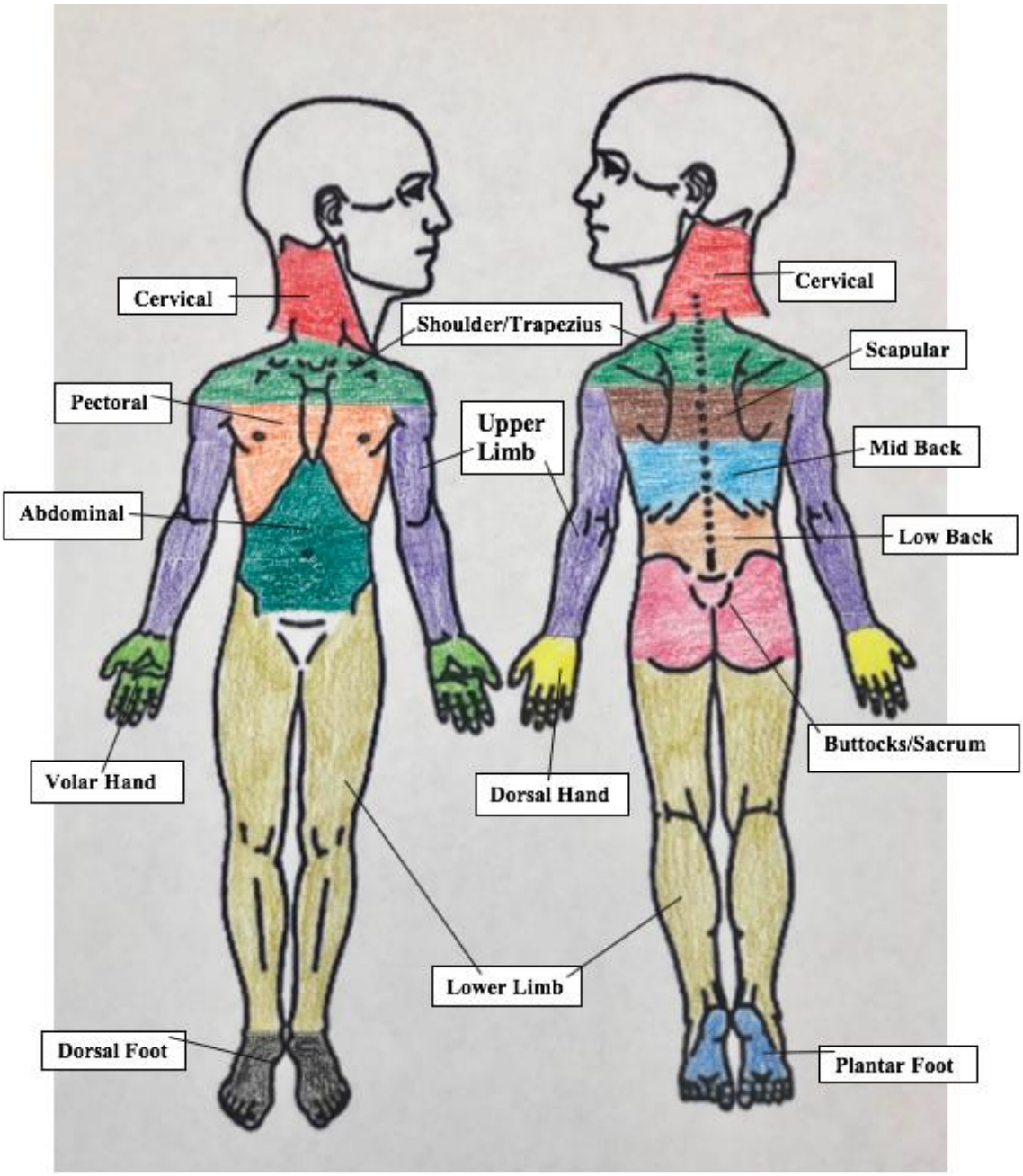

Figure 3: McGill pain diagram and body regions.

Data was primarily analyzed through descriptive statistics. Association between neck flexion and pain measures were analyzed using the Pearson and Spearman coefficient

correlations methods to measure the strength of the association between two continuous variables. These tests use values between -1 and 1. If the correlation = 1, there is a perfect positive correlation, if the correlation = 0 there is no correlation, and if it = -1 there is a perfect negative correlation.

Budget:

Subjects who provided written consent were not liable for any tools or materials during the study. The G-Pro iPhone 8 plus app is free through the App Store on an apple mobile device or can be found using Google Play for Android mobile device users and was used by the researcher (JS). There was not a money compensation for students who participated in the study. Each of the participants' measurements during the study was captured individually within the app and transferred to Microsoft Excel spreadsheets with no additional tools needed by the participants.

CHAPTER IV: RESULTS, DISCUSSION AND CONCLUSION

Results:

Trials utilizing the Goniometer application with the iPhone 8 plus were conducted prior to recruitment of the dental hygiene students. The purpose of the trials was to ensure reliability of the researcher (JS) using the G-Pro application aligning the phone according the correct axis at the external auditory meatus to the commissure of the lip. The trials were performed on the right side of the face on the volunteers to mimic the proposed study on dental hygiene students. Informed consent was emailed to Patricia Siegel, an occupational therapist and Assistant Professor at the University of New Mexico. The consent forms were then forwarded to occupational therapy (OT) students from the University's School of Medicine inviting them to volunteer in the trial sessions. Those who consented to participate returned the signed consent forms to Patricia Siegel.

Nine OT students volunteered to participate and a total of 50 trials were completed measuring neck flexion with an intra-rater agreement of plus or minus 5° with the G-Pro application performed by myself and with a standard goniometer used by Patricia. On the first day of trials measuring neck flexion there was 40 trials completed, including practice, and examiners were in agreement of 71%. The second day involved 10 trials of measuring neck flexion and examiner agreement was 90%.

Next, a recruitment email was sent to 24 second year dental hygiene students from the University of New Mexico's dental hygiene program and attached was the consent form to participate in the study. All 24 (N=24) senior dental hygiene students consented to participate in the study and returned the consent form via handout. Twenty-two participants were female and

two were male all whom were adults and could consent for themselves. Participants' age ranged from twenty-one to forty-seven years of age with a mean age of twenty-seven.

All measurements taken were performed on the right side of the face once the correct phone axis was established. One-hundred percent (n=24) of participants measured had greater than 20° of neck flexion on initial measurement. The minimum degree of neck flexion was 30°, maximum was 63°, and the mean degrees of neck flexion was 42.5°. The McGill Pain Questionnaire asks participants to rate pain on a linear scale with a range of no pain to the worst possible pain scaled from 0-10. Four (17%) participants rated their pain as a 1. The highest rated number was a 7 by 8% (n=2) of participants and the mode was a 2 selected by 29% (n=7). *(See Table 1.)*

	N	Mean	Median	Min	Max
Age	24	27.50	24.00	21.00	47.00
Degrees of neck Flexion	24	42.50	40.50	30.00	63.00
Pain (0-10)	24	3.42	3.00	1.00	7.00

Table 1: Characteristics of participants

On a separate form, participants answered two additional questions. Question one asks; Do you wear dental loupes when performing manual scaling during patient care? One-hundred percent (n=24) of participants reported yes. Question two asks; Have you had an injury to the head, shoulder, or neck region prior to dental hygiene school? Ninety-two percent (n=22) reported to having no prior injury and 8% (n=2) reported yes.

By categorizing the participants degree of neck flexion imitating the Branson's Posture Assessment Instrument, PAI, 0% were in the healthy range ≤ 20°, 67% (n=16) fell into the compromised range >20° and ≤ 45°, and 33% (n=8) were in the harmful range > 45°. Shown below in Figure 4, the majority of participants are in a compromised range of neck flexion.

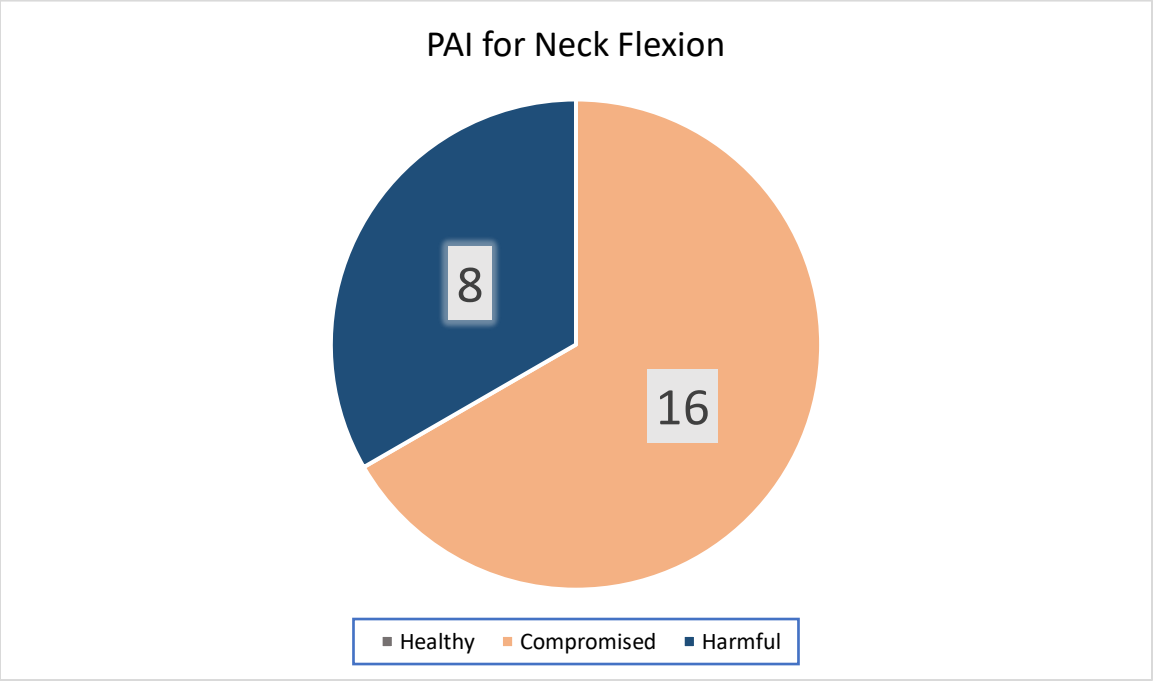

Figure 4: Participants who were in a healthy, compromised, or harmful range of neck flexion.

From the McGill Pain Questionnaire, the top five pain associated words that were selected on the form was aching 71% (n=17), tiring-exhausted 58% (n=14), throbbing 33% (n=8), tender 25% (n=6), and heavy 21% (n=5). Participants were asked to rate mild, moderate, or severe with the pain associated word. With those who reported aching pain, 53% (n=9) had mild pain and 47% (n=6) had moderate. Those with tiring/exhausting pain was 43% (n=6) mild, 50% (n=7) moderate and 7% (n=1) severe. Throbbing pain was 62.5% (n=5) mild and 37.5% (n=3) moderate. Tender pain reported 17% (n=1) mild and 83% (n=5) moderate. Heavy pain was 40% (n=2) mild and 60% (n= 3) moderate. *(See Figure 5)*

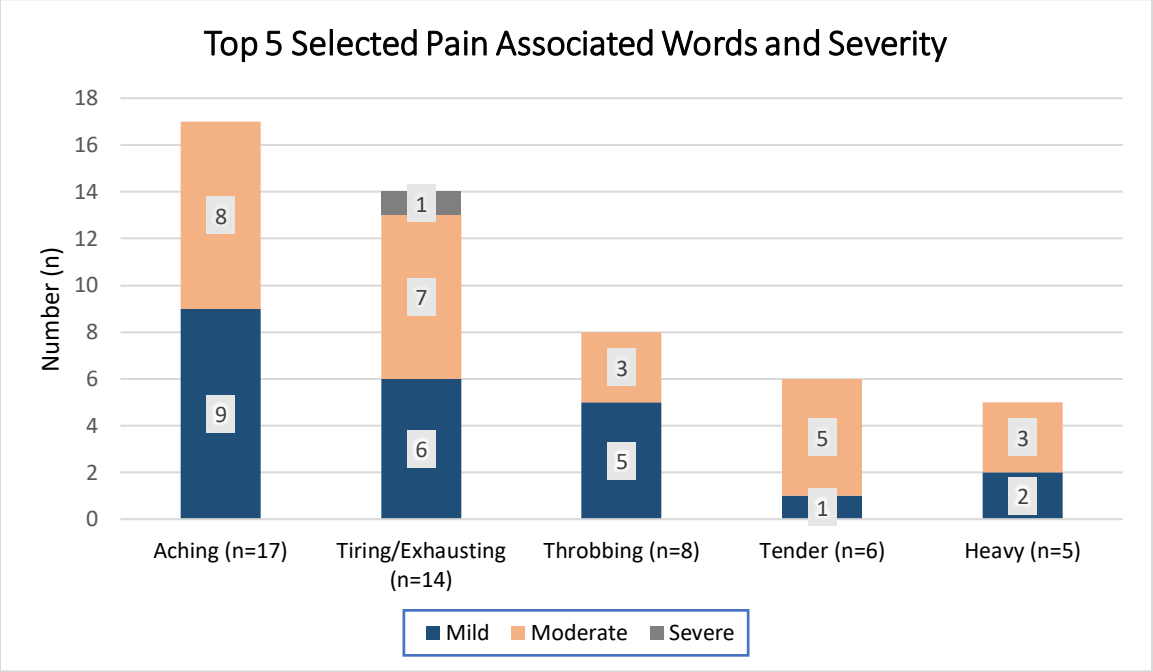

Figure 5: Top 5 pain associated words and severity selected from participants.

Expressed below in Figure 6, the top 5 body regions selected to have pain or problems from the body diagram on the McGill Pain Questionnaire was 63% (n=15) shoulder/trapezius, 50% (n=12) cervical, 46% (n=11) low back, 36% (n=9) scapular, and 21% (n=5) mid back.

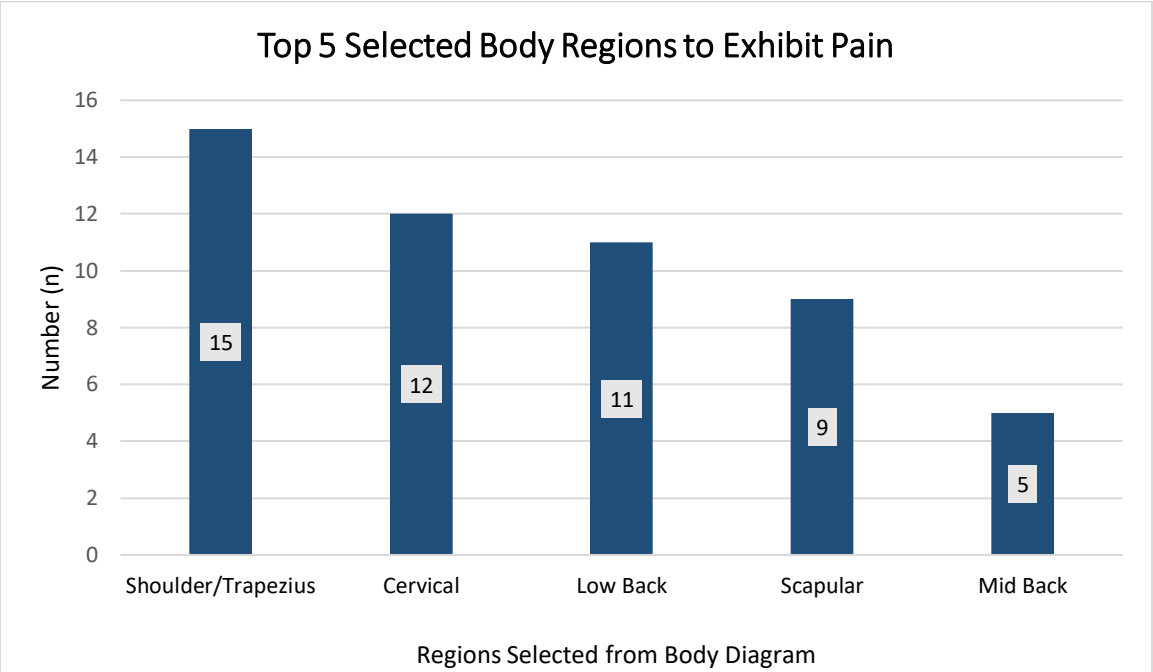

Figure 6: The top 5 body regions selected to have pain or problems by participants.

Shoulder/Trapezius was the body region most selected from all participants with 63% (n=15) of participants reporting pain/problems in this area. Of the 63%, the mean degree of neck flexion was 43°, the minimum of 31° and the maximum of 63°. Of those, 60% (n=9) participants were recorded in a compromised degree of neck flexion and 40% (n=6) were recorded in a harmful degree of neck flexion. *(Figure 7)*

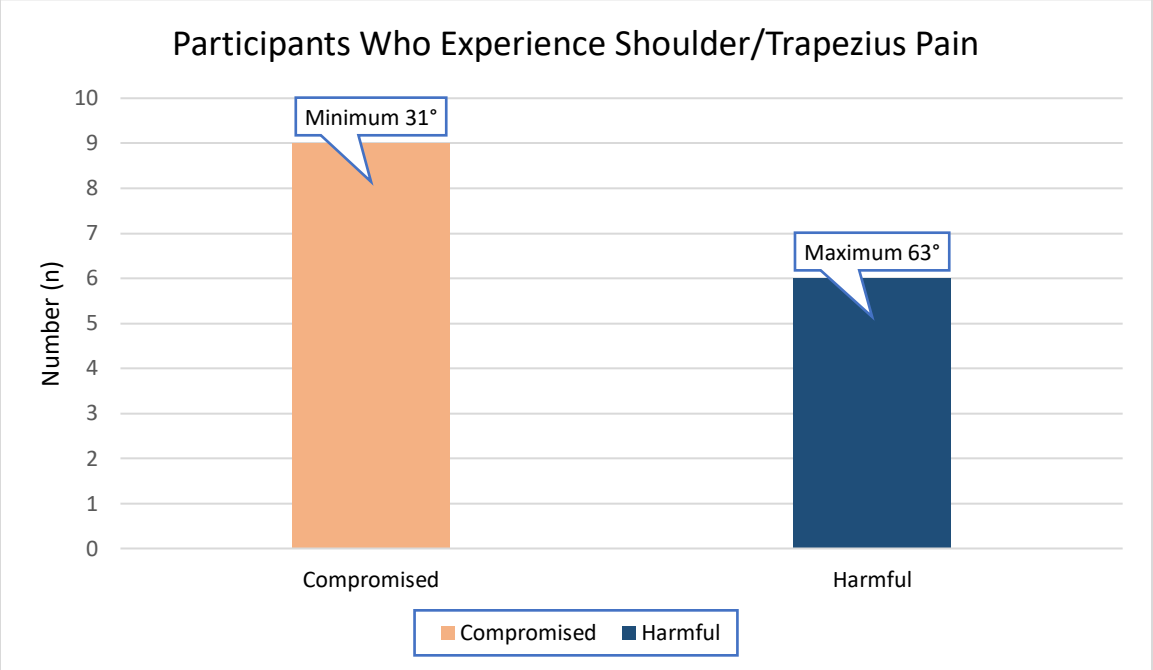

Figure 7: Participants degree of neck flexion using the PAI in those who had shoulder/trapezius pain.

The second most reported region of pain was the cervical region with 50% (n=12) of participants who selected this region as being a problem. Of the 50%, the mean degree of neck flexion was 43°, the minimum 31° and the maximum 55°. Showing 75% (n=9) participants in a compromised state of neck flexion and 25% (n=3) in a harmful state. Shown below in Figure 5 are those who experienced cervical pain, the PAI category, and the minimum and maximum of neck flexion in degrees. *(See Figure 8)*

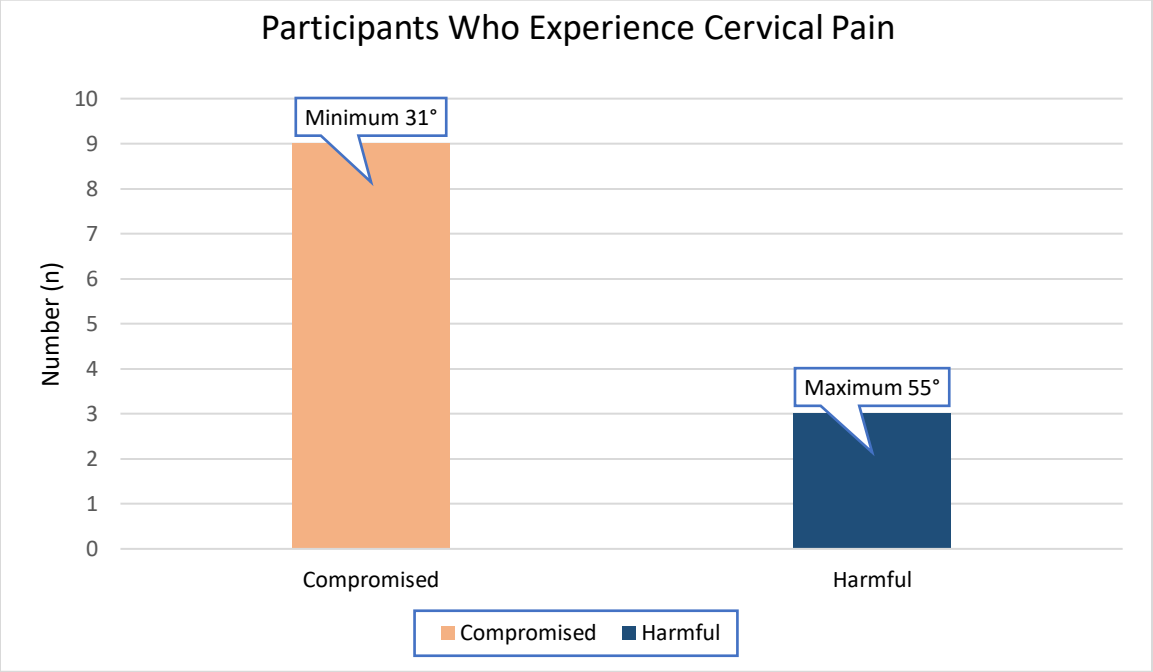

Figure 8:Participants degree of neck flexion using the PAI in those having cervical pain.

Many participants reported pain or problems in more than one region from the body diagram. There was 41.6% (n=10) of participants who reported having shoulder/trapezius and cervical pain. The mean degree of neck flexion was 43°, the minimum was 31° and the maximum was 55°. The mean age of this group was 26, the minimum was 22 and the maximum age was 34. Nine were female and one was male. Of the 41.6%, aching and tiring/exhausting were the top two pain associated words selected. Aching of 60% (n=6) with 33% (n=2) feeling mild pain and 67% (n=4) feeling moderate pain. Tiring/exhausting was 70% (n=7) with 57% (n=4) feeling mild pain, 29% (n=2) moderate pain, and 14% (n=1) severe pain. Of the 41.6% of participants there was one that reported a yes to Question #2 on the additional survey, as having a previous injury to the head, shoulder, or neck region prior to dental hygiene school.

Further analysis of Pearson and Spearman tests correlations *(Table 2)* were used in attempt to find association between neck flexion and pain measures. In this study, no measures were found to be significantly associated with correlation coefficients using these tests.

	Pearson Correlation Test	**Spearman Correlation Test**
Pain		
Pain (0-10)		
Coefficient	0.31	0.29
P-value	0.14	0.17
NumPain		
Coefficient	0.15	0.35
P-value	0.48	0.09
TotPainScore		
Coefficient	0.21	0.38
P-value	0.33	0.07
NumPainLoc		
Coefficient	0.03	0.16
P-value	0.88	0.44

Table 2: Correlation Coefficient and p-value between degrees of neck flexion and pain measures (n=24).

Discussion:

Previously referenced literature on MSDs and the prevalence of dental hygiene students suffering from MSDs is still lacking.[1,5] This is thought to be because the lack of research to support that MSDs appears in early education with dental hygiene students. The same factors affecting dental professionals with WMSDs have been the same factors affecting dental hygiene students in the neck, shoulder, wrist, and lower back.[5] More commonly, MSDs are reported with years of practicing in dental hygiene but the limited reported prevalence in dental hygiene students could be due to the lack of research with dental hygiene students.[1] As Hayes, et Al states in a study, that in more recent years it's been suggested that dental hygiene students are experiencing MSDs early on and this can be agreed upon by this study with neck flexion because second year dental hygiene students reported already experiencing MSDs early in education.[5]

The purpose of this study was to investigate the prevalence of dental hygiene students being affected by musculoskeletal pain in the neck region in early dental hygiene education and if musculoskeletal pain was associated with the student's degrees of forward neck flexion during manual scaling procedures. This observational study found, as literature suggests, that dental hygiene students start to develop musculoskeletal pain in the neck region in early education with improper operator positioning of neck flexion. The majority of the participants were female and two were male in this study and all twenty-four participants had a neck flexion measurement of over 20°. More than half of the participants were in a compromised degree of neck flexion of >20° and $\leq$45°. This would suggest that musculoskeletal pain reported in the neck region can be associated with the degrees of neck flexion. Literature states the appropriate degrees of forward neck flexion should be $\leq$ 20°.[17,18,19,20]

Majority of participants reported no prior injury to the head, neck or shoulder region

prior to dental hygiene school and two participants reported yes. This study focused on forward neck flexion and musculoskeletal pain in the neck region, half of the participants reported cervical pain. Of those who reported cervical pain (n=12) there were nine participants who had a neck flexion measurement that was compromised and three that were harmful. Another large percentage of 63% (n=15) reported shoulder/trapezius pain with nine compromised and six with a harmful degree of neck flexion. Cervical and shoulder/trapezius were the two most common areas of the body that participants reported to have their pain or problems. The third most common was the low back region. With all participants having a neck flexion over the healthy recommended range, and results showed an impact on other regions of the body and not secluded to the neck, it is likely that other poor postures throughout the body were present.

The previously mentioned study by Morse et., al, concluded that of the 27 dental hygiene students who were investigated in the study, with a mean age of 24, 79% were found working with a bent neck often or very often. Similar to this study that had a mean age of 27, one-hundred percent of the participants were found working with a neck bend forward.[15]

All twenty-four participants reported wearing dental loupes when performing manual scaling on patients. Dental loupes are magnification lenses that are an intervention to help decrease neck flexion. Literature states that neck pain is a natural consequence of forward neck flexion over prolonged periods of time. These loupes should allow the dental hygienists to magnify their working area without putting neck flexion and stress on themselves.[22] As the article by Garcia et., al, suggested, dental hygiene students should implement dental loupes in pre-clinical work to help with posture and vision clarity.[11] In this study, all participants wore loupes, but musculoskeletal pain was still present.

A factor that could affect the amount of poor posture is inadequately fitted loupes. Dental

loupes have three variables to assess when being fitted: working distance, declination angle, and the frame size. It is possible that the working distance can be measured too close, the declination angle not steep enough, or the frame size being too small which limits the space the microscopes can be placed thus effecting the declination angle. With all of these variables measured correctly, a dental professional should be able to flex their neck at 20° or less and ultimately improve postures that can contribute to MSDs and pain.[18] These variables should be performed correctly by those fitting the loupes on dental providers, but it is probable that they are not. However, this is just a theory and examiners did not include this assessment in the study.

Limitations:

Limitations to this study include small sample size, the degree of neck flexion gathered does not represent an average neck flexion when performing manual scaling, and procedures with manual scaling could have varied with participants. Sample size of 24 is small and therefore limiting generalizations. Participants measurement of neck flexion was only taken at one time during a manual scaling procedure and does not represent an average of neck flexion in the students. The procedures involving manual scaling could have varied when the neck flexion measurement was gathered; i.e. scaling and root planing versus recall prophylaxis.

Participants were actively working in a clinical setting with patients and the wear of personal protective equipment(PPE), was a limitation in this study because the degrees of neck flexion are to be gathered from measuring the external auditory meatus aligned with the commissure of the lip. In this case, the protective mask covers a large portion of the face. Best attempts were made to align the phone axis accordingly.

The measurement of neck flexion was aimed to evaluate forward neck flexion. It can be challenging when measuring the degrees of neck flexion to not just have forward neck flexion

and it's possible the participant could have been engaged in lateral neck flexion at the same time during patient care. This could have been a limitation to the study because neck flexion was focused on gathering the measurement from the external auditory meatus aligned to the commissure of the lip. Best attempts to evaluate forward neck flexion were made but this limitation could have impacted the results if participants were lateral flexing.

Another limitation in this study is related to dental loupes. As discussed, if dental loupes are fitted to the user correctly, the user should be able to flex no more than 20° and ultimately improve posture. In this study there was no evaluation on dental loupes used by the participants to determine if they had been fitted to the user correctly. Assumingly, if the dental loupes used by the participants had not been fitted correctly, the degrees of neck flexion may be a result of an incorrect fit.

Conclusion:

Failure to maintain proper ergonomic operator positioning, specifically neck flexion ≤20°, during a manual scaling procedure in early dental hygiene education was supported by 50% (n=12) of participants who reported cervical pain or problems. The top five selected areas to have pain or problems were shoulder/trapezius, cervical, low back, scapular, and mid back. All participants had a neck flexion measurement over the recommended healthy degrees of ≤20°. The most reported region to have pain or problems was the shoulder/trapezius region. All participants reported wearing dental loupes during manual scaling procedures. Literature has already suggested these be worn to help with posture and clarity and therefore other variables to manage these issues should be questioned.

Recommendations for Further Research:

When conducting further research on the prevalence of musculoskeletal disorders in

dental hygiene students in early education it would be important to conduct a study on a larger population to increase generalizability. In a future study like this it would be interesting to determine how many dental hygiene students were previously or currently dental assistants and for how long. In the study by Morse et, Al, the dental hygiene students who were previously dental assistants showed 89% who reported to work with a bent neck often or very often.[15]

It would also be important to research specifically the type of care that is being provided; i.e. scaling and root planning, heavy versus light tartar, or a recall prophylaxis. Adjunct to this, I would like to inquire whether dental hygiene students understand good posture and if they practice good posture to their best ability. Research on exercises and stretches that have been found most helpful for dental professionals to reduce musculoskeletal pain would also be informative to study with dental hygiene students on what is most affective for that target population in early education and how likely students would be to practice those exercises.

Literature suggests that education of good posture, ergonomics, and training in ergonomics to increase awareness should be implemented into dental hygiene education in hopes to decrease MSDs early on.[1] In this research study, the participants received ergonomic education during their first year of dental hygiene school so it would be important to investigate if the dental hygiene students feel that they adequately understand ergonomics and what is healthy versus unhealthy in a workplace that is already at a higher risk for MSDs.

It's found that dental professionals are at an increased risk of MSDs or WMSDs and that MSDs is one of the most common occupational health hazards.[1,4] Assuming that dental loupes used by dental hygiene students are well fitted with the correct working distance, declination angle, and frame size for the user, it would be important to study habits that may be contributing to MSDs either during dental hygiene clinical care or outside of the workplace. Research is

suggesting that those who work with computers are at a risk for MSDs. Those who worked on computers every day for their career had more shoulder, neck, wrist, and elbow pain and a study found that 58% of those who worked for more than 4 hours a day on a computer were diagnosed with TNS.[15,23] Therefore, future research on outside variables that could create an even bigger risk for MSDs in dental hygiene students should be looked into.

Chapter V: Article for Submission

Journal of Dental Hygiene

Title: Poor Ergonomics and Neck Flexion: Evaluating the Prevalence of Musculoskeletal Neck Pain in Dental Hygiene Students

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Key Words: Goniometer, flexion, musculoskeletal disorders

ABSTRACT

Purpose: The purpose of this study was to investigate the prevalence of dental hygiene students being affected by musculoskeletal pain in the neck region in early dental hygiene education and if musculoskeletal pain was associated with the participants degrees of forward neck flexion during manual scaling procedures.

Methods: This observational study included 50 practice trials to test reliability using a Goniometer application (G-Pro) on an iPhone 8 plus to measure neck flexion. Twenty-four dental hygiene students consented to participate in the study and degrees of neck flexion was taken thirty minutes into a manual scaling procedure in an already established educational setting. After neck flexion was gathered participants received a short form McGill Pain Questionnaire and additional survey to complete. Descriptive statistics were used to analyze all data.

Results: A total of 24 dental hygiene students consented to participate in the study. All participants showed neck flexion exceeding 20° during a manual scaling procedure. In total, 67% (n=16) were in a compromised range and 33% (n=8) were in a harmful range. From the McGill Pain Questionnaire, the top 5 pain descriptors selected was aching 71% (n=17), tiring-exhausted 58% (n=14), throbbing 33% (n=8), tender 25% (n=6), and heavy 21% (n=5). The top 5 body regions from the body diagram selected to have pain/problems was 63% (n=15) shoulder/trapezius, 50% (n=12) cervical, 46% (n=11) low back, 36% (n=9) scapular, and 21% (n=5) mid back. On a linear pain scale, participants reported pain with 17% (n=4) as a 1, the highest rated number was a 7 by 8% (n=2) and the mode was a 2 selected by 29% (n=7). All participants reported wearing dental loupes during manual scaling.

Conclusion: The work environment and tasks for dental professionals have been proven to increase the risk for musculoskeletal disorders. Studies that have been done in the past suggest that experienced dental hygienists suffer from musculoskeletal disorders; however, studies are lacking in the dental hygiene student's population and this study was an attempt to expand the research. Failure to maintain proper ergonomic operator positioning, contributing to neck pain, specifically neck flexion $\leq 20°$, during a manual scaling procedure in early dental hygiene education was supported by 50% (n=12) of participants who reported cervical pain or problems. Another 63% (n=15) of the participants reported shoulder/trapezius pain. All participants reported wearing dental loupes during manual scaling procedures and two of the twenty-four reported an injury prior to dental hygiene school. Future research on the topic should investigate on a larger sample size, gathering an average of neck flexion during a clinical session and assess dental loupes.

Introduction:

Musculoskeletal disorders, MSDs, are one of the most important occupational health issues in health care workers.[1] Poor ergonomics is one of the leading factors to developing musculoskeletal disorders.[2] MSDs are identified as injuries to the human body support system such as the ligaments, tendons, muscles, nerves, blood vessels, bones, and joints.[1,3] The goal of ergonomics is to develop a safe and comfortable working environment. This would then prevent health problems and improve productivity.[10,11] Numerous articles have been published expressing an increased risk for dental hygienists to develop MSDs and the high prevalence rate for WMSDs in dental professionals at 64%-93%.[3]

Poor ergonomics such as excessive neck flexion, constrained working postures, excessive static and peak loading of the upper trapezius and the forearm extensor muscles all play a role in developing WMSDs. The physical demands for the upper extremities in dental hygiene practice, create an increased risk for developing WMSDs in the neck and shoulders.[2] Additionally, other factors exist such as limited working fields, unique movements, fine and repetitive tasks, and static postures.[5,7]

MSDs are especially common in experienced dental hygienists but have also been reported in dental hygiene students.[2] Early retirement within the field of dental hygiene and career changes have been said to be a result of WMSDs.[2,3] The regions of the body that are being reported in pain are the back, neck, hand, wrist, shoulders, as well as lower extremities such as hips, thighs, and knees which have all been documented as areas in developing WMSDs.[1,5] Symptoms of this disorder will involve swelling, pain, tenderness, numbness, tingling, and loss of strength in the structures that are affected. The condition of MSDs can be slight and recurrent or can be severe and incapacitating.[4] This is often a result of cumulative trauma to these areas.[1,3]

Studies continue to support existing evidence of high prevalence's of MSDs in dental hygienists and in a year-long study, 82% reported with MSDs in the neck and 33% of those participants were diagnosed with TNS.[12] Tension neck syndrome, TNS, can be of diagnosis from risk factors of MSDs like sustained exertion, static and awkward postures, excessive neck bending,. TNS involves painful neck spasms and trigger points that come from a specific type of work loading common in dental hygiene.[15] Work loading can be explained as the amount of stress put on the muscles during a specific task.[13] TNS symptoms also include stiffness around the neck and limited movement, pain radiating down to the arms and between the shoulder blades, and palpable hardness in the neck.[16] Dental hygiene students need to understand the importance of healthy degrees of neck flexion to prevent neck symptoms, which is less than or equal to 20 degrees.[17,18,19,20]

Studies show that the neck is the most common region reported to have pain. A three-year study on dental hygiene students showed a prevalence of neck pain increasing from a 66% to a 68.3% from 2008 to 2010.[5] A more recent study of dental hygienists found that the neck and shoulders had excessive demands during manual scaling and 90% of participants showed neck flexion over the recommended limits.[2]

Loupes allow the dental hygienists to magnify their working area without putting neck flexion and stress on themselves. [22] Dental loupes are a beneficial advantage when fitted to the user correctly. Ill-fitted dental loupes could cause the dental professional to participate in poor ergonomics. The three variables to assess are the working distance, declination angle, and frame size. An optimal working distance should be 14-20 inches but may vary depending on the operator's size.[16,18] The declination angle should be steep enough to allow clarity into the working field without excessive neck flexion. The bigger the frame size that sits on the cheek

allows for the microscopes to be placed farther down, thus resulting in a better declination angle.[18] The prevalence of this disorder has been more commonly reported with years of practicing in dental hygiene, but the limited reported prevalence in dental hygiene students could be due to the lack of research with dental hygiene students.[1] Musculoskeletal disorders appear in dental hygiene students early in their clinical education. Dental hygiene student's failure to implement and maintain proper ergonomic operator positioning, specifically neck flexion in excess of 20°, during manual scaling will contribute to neck pain early in education.

Methods and Materials:

This observational research approach focused on studying ergonomics in dental hygiene students. Previous studies reviewed have examined MSDs among experienced dental hygienists and dentists, but very few studies have been conducted on the MSDs in dental hygiene students. The aim of this study was to evaluate dental hygiene students on the degrees of neck flexion when performing manual scaling in an established educational clinical setting. By utilizing the Goniometer pro, G-Pro, application with the iPhone 8 plus, the participants degrees of neck flexion were measured. The present app for the iPhone 8 plus uses a built-in accelerometer sensor and digital display to measure angles. The University of New Mexico's Human Subject Review Committee reviewed and approved the study.

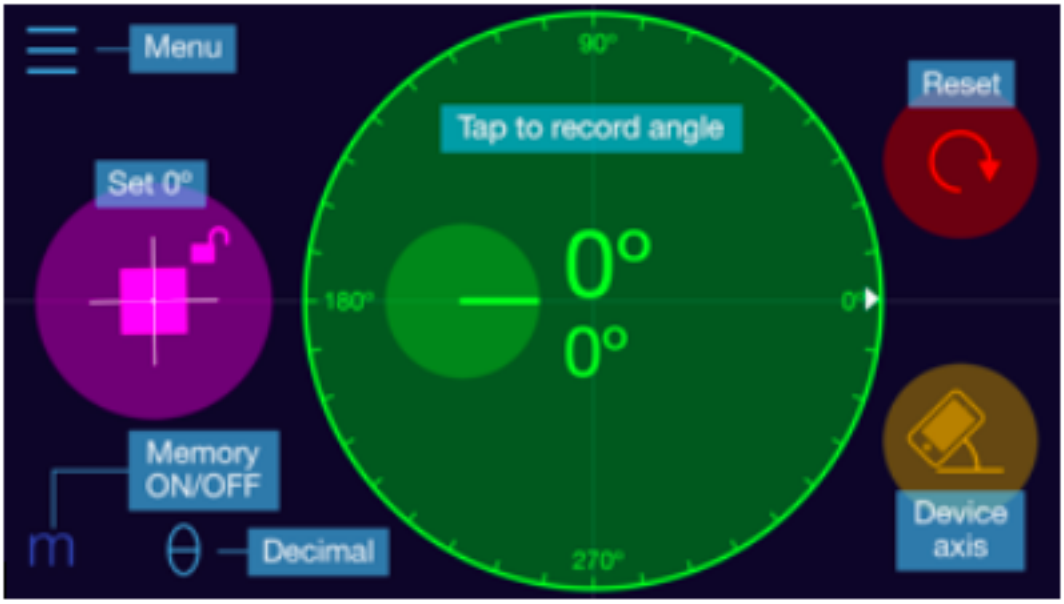


Figure 9: Digital display of the G-Pro application.

Before studying the dental hygiene students, 50 trials on occupational therapy students were conducted to test the researchers' reliability using the G-Pro application after informed consent was obtained. An occupational therapist faculty member supervised the dental hygiene examiner while conducting the trial sessions using the G-Pro application to practice taking the measurements of neck flexion and then compared the G-Pro measurement with a standard goniometer measurement. There was an intra-rater agreement of plus or minus 5° with the G-Pro application performed by the dental hygiene researcher and with a standard goniometer used by occupational therapist faculty.

The target population for this study included second year dental hygiene students. A convenience sample of a maximum of 24 dental hygiene students from the university's dental hygiene program were selected. Inclusion criteria for this study were those who were second

year dental hygiene students, in the final senior semester, and adults who could consent for themselves.

The research was conducted in an established educational clinical setting and involved normal clinical dental hygiene education. Participants were selected and measured using the G-pro app during any time in the study period and the criteria for selection was a manual scaling procedure. The degrees of neck flexion were gathered 30 minutes into a manual scaling procedure on the selected participants for the day by tapping the devices screen and capturing the measurement. The iPhone 8 plus was placed at the external auditory meatus, test position parallel or 0°, the correct phone axis was adjusted to the test position and aligned with the commissure of the lip to gather the measurement. After participation in the study the students obtained a short form McGill Pain Questionnaire and an additional survey to complete.

Below in Figure 10 is the alignment from the external auditory meatus to the commissure of the lip. The center of the iPhone was placed at the external auditory meatus at the test position parallel or 0°. The phone was kept centered over the external auditory meatus and the moving arm, in this case present on the phone, would follow the flexion of the participants. Figure 10 also shows how degrees of neck flexion was gathered with participants when in an educational clinic setting thus wearing personal protective equipment, PPE.

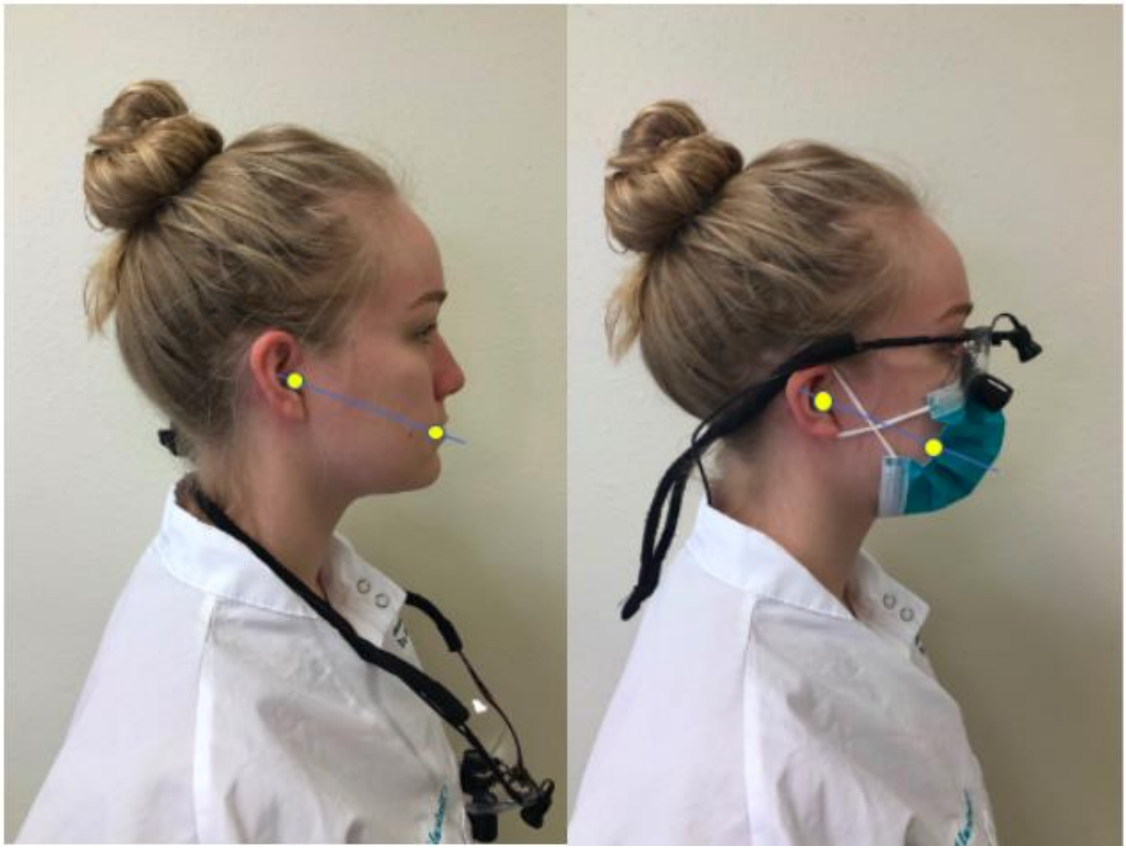


Figure 10: Measure points without and with mask.

The questionnaire included a full body pain diagram that participants were instructed to mark on the diagram where they had any pain or problems. There were columns that the participants indicated the level of pain as either mild, moderate, or severe for the fifteen different pain associated words; if the words did not apply they were to be left blank. In addition to the short form McGill Pain Questionnaire the students were asked to answer a few additional questions as Yes or No. The questions were; Do you wear dental loupes when performing manual scaling during patient care? Have you had an injury to your head, shoulders, or neck regions prior to dental hygiene school?

The criteria for the evaluation assessment of neck flexion included a healthy range (1) at ≤ 20°, a compromised range (2) at >20° and ≤ 45°, and the harmful range (3) at >45° based off of Branson et al.'s Posture Assessment Instrument (PAI). The participants data for neck flexion was grouped into one of the above categories. Data were primarily analyzed through descriptive statistics. Association between neck flexion and pain measures were analyzed using the Pearson and Spearman correlations methods to measure the strength of the association between two continuous variables.

Results:

All twenty-four (N=24) senior dental hygiene students consented to participate in the study. Twenty-two participants were female and two were male all whom were adults and could consent for themselves. Participants' age ranged from twenty-one to forty-seven years of age with a mean age of twenty-seven. All measurements taken were performed on the right side of the face once the correct phone axis was established. One-hundred percent (N=24) of participants measured had greater than 20° of neck flexion on initial measurement. The minimum degree of neck flexion was 30°, maximum was 63°, and the mean degrees of neck flexion was 42.5°.

By categorizing the participants degree of neck flexion imitating the Branson's PAI, 0% were in the healthy range of ≤ 20°, 67% (n=16) fell into the compromised range >20° and ≤ 45°, and 33% (n=8) were in the harmful range > 45°. Shown below in Figure 11, the majority of participants are in a compromised range of neck flexion.

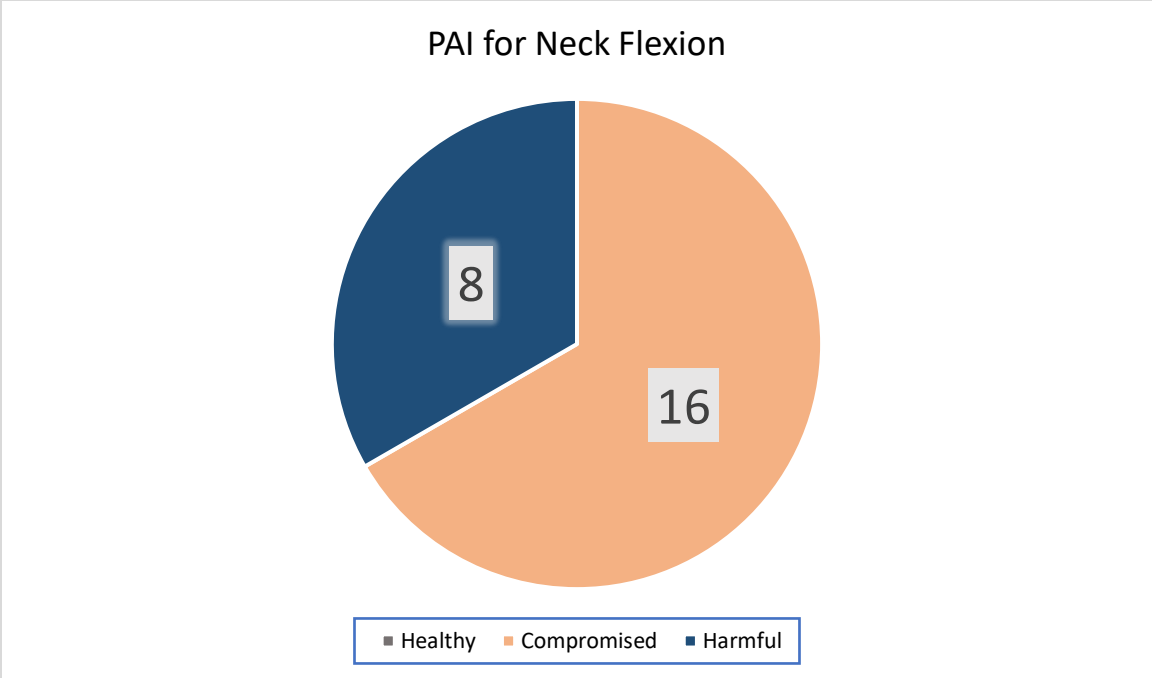


Figure 11: Participants who were in a healthy, compromised, or harmful range of neck flexion.

The McGill Pain Questionnaire asks participants to rate pain on a linear scale with a range of no pain to the worst possible pain. Once all questionnaires were returned the scale was ranked from 0-10. Four (17%) participants rated their pain as a 1. The highest rated number was a 7 by 8% (n=2) of participants and the mode was a 2 selected by 29% (n=7). On a separate form, participants answered two additional questions: 1) Do you wear dental loupes when performing manual scaling during patient care? 100% (n=24) of participants reported yes. 2) Have you had an injury to the head, shoulder, or neck region prior to dental hygiene school? 92% (n=22) reported having no prior injury and 8% (n=2) reported yes.

From the McGill Pain Questionnaire, the top five pain associated words that were selected on the form was aching 71% (n=17), tiring-exhausted 58% (n=14), throbbing 33% (n=8), tender 25% (n=6), and heavy 21% (n=5). Participants were asked to rate mild, moderate, or severe with the pain associated word. With those who reported aching pain, 53% (n=9) had mild pain and 47% (n=6) had moderate. Those with tiring/exhausting pain was 43% (n=6) mild, 50% (n=7) moderate and 7% (n=1) severe. Throbbing pain was 62.5% (n=5) mild and 37.5% (n=3) moderate. Tender pain reported 17% (n=1) mild and 83% (n=5) moderate. Heavy pain was 40% (n=2) mild and 60% (n= 3) moderate. Shown below in Figure 12

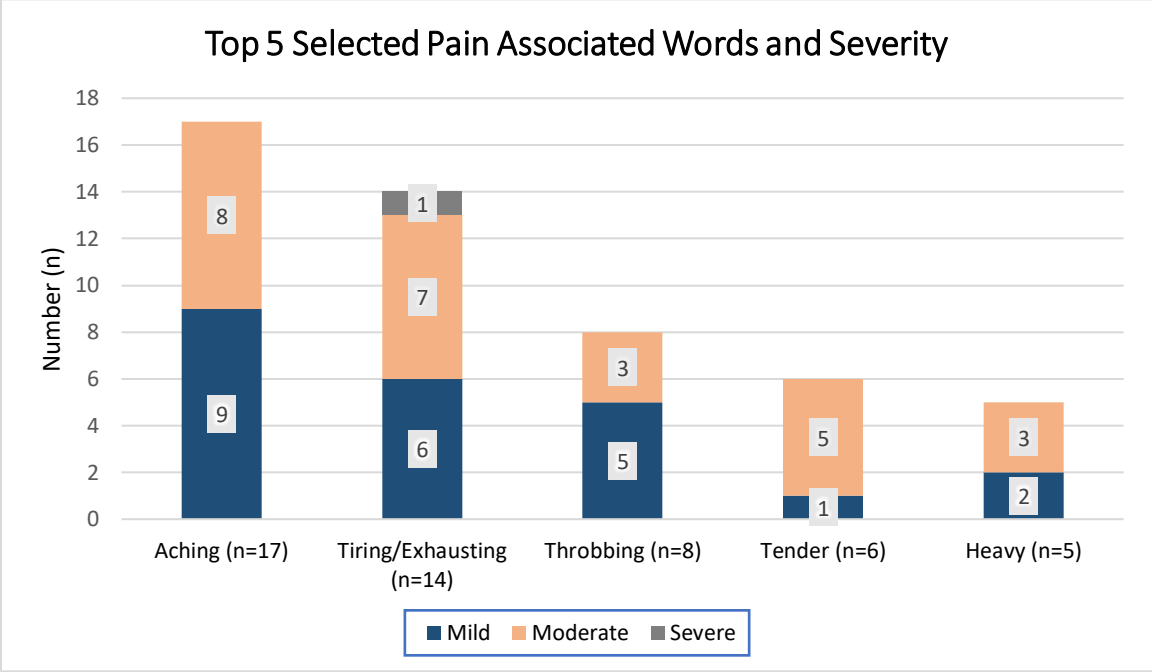


Figure 12: Top 5 pain associated words and severity selected by participants.

The top 5 body regions selected to have pain or problems from the body diagram on the McGill Pain Questionnaire was 63% (n=15) shoulder/trapezius, 50% (n=12) cervical, 46% (n=11) low back, 36% (n=9) scapular, and 21% (n=5) mid back. Shown below in Figure 13.

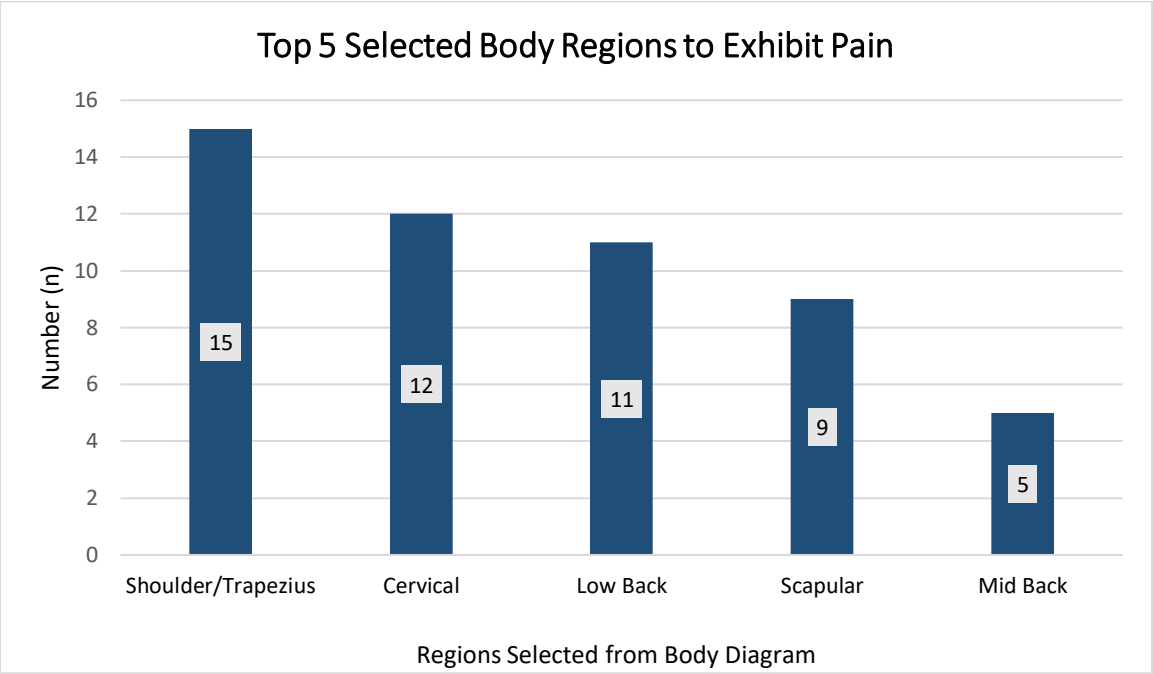


Figure 13: Top 5 body regions to have pain or problems.

Shoulder/Trapezius was the region most selected from all participants with 63% (n=15) of participants reporting pain/problems in this area. Of the 63%, the mean degree of neck flexion was 43°, the minimum of 31° and the maximum of 63°. Of those, 60% (n=9) participants were recorded in a compromised degree of neck flexion and 40% (n=6) were recorded in a harmful degree of neck flexion. Shown below in Figure 14.

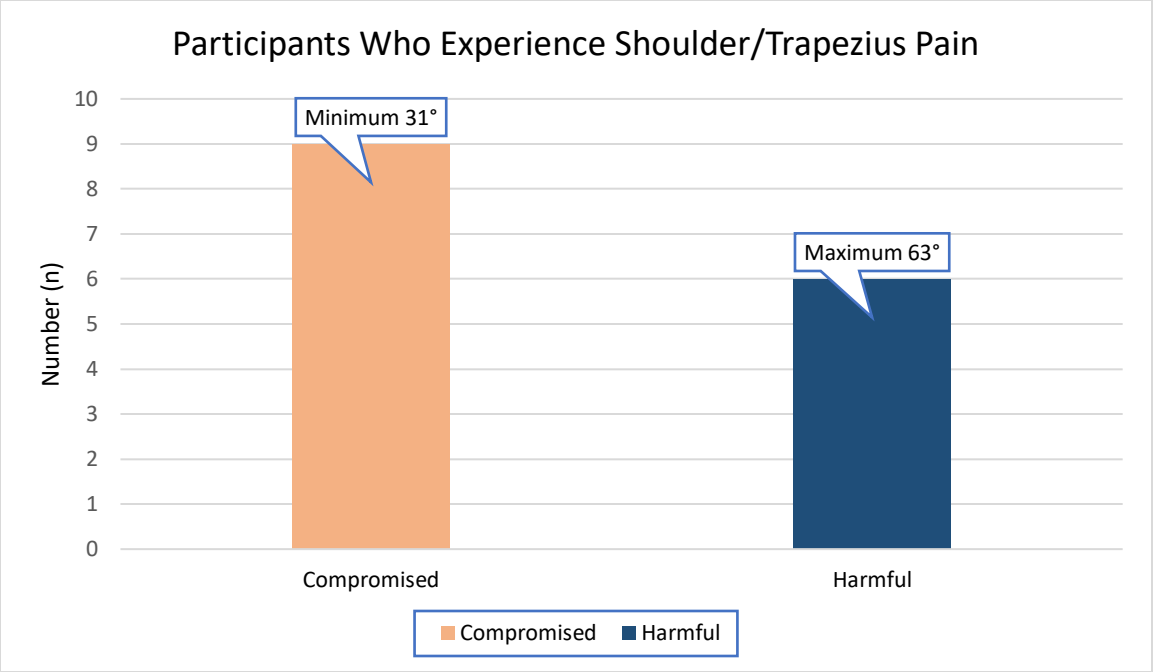


Figure 14: Participants degree of neck flexion using the PAI and those who reported having shoulder/trapezius pain.

The second most reported region of pain was the cervical region with 50% (n=12) of participants who selected this region as being a problem. Of the 50%, the mean degree of neck flexion was 43°, the minimum 31° and the maximum 55°. Showing 75% (n=9) participants in a compromised state of neck flexion and 25% (n=3) in a harmful state. Shown below in Figure 5 are those who experienced cervical pain, the PAI category, and the minimum and maximum of neck flexion in degrees. (*Figure 15*)

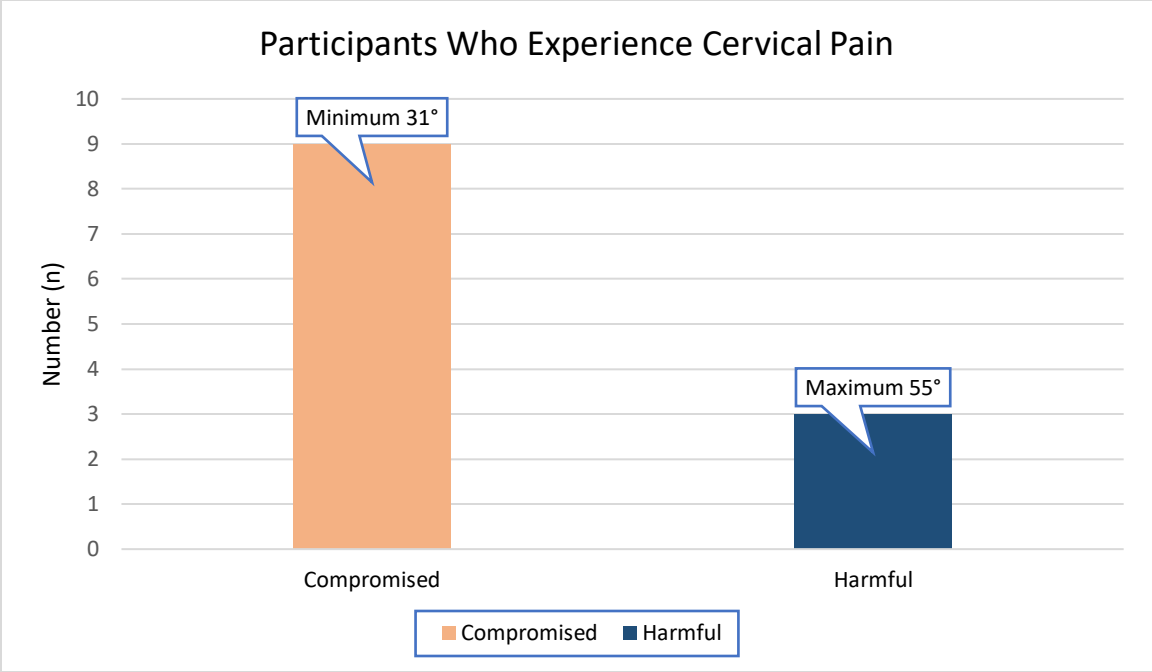


Figure 15: Participants degree of neck flexion using the PAI and those who reported cervical pain.

Discussion:

The same factors affecting dental professionals with WMSDs have been the same factors affecting dental hygiene students in the neck, shoulder, wrist, and lower back.[5] More commonly, MSDs are reported with years of practicing in dental hygiene but the limited reported prevalence in dental hygiene students could be due to the lack of research with dental hygiene students.[1] Previously referenced literature on MSDs and the prevalence of dental hygiene students suffering from MSDs is still lacking.[1,5] Literature states the appropriate degrees of forward neck flexion should be $\leq 20°$.[17,18,19,20]

The purpose of this observational study was to investigate the prevalence of dental hygiene students being affected by musculoskeletal pain in the neck region in early dental hygiene education and if musculoskeletal pain was associated with the participants degrees of

forward neck flexion during manual scaling procedures. This study found, as literature suggests, that dental hygiene students start to develop musculoskeletal pain in the neck region in early education with improper operator positioning of excessive neck flexion.

This study focused on forward neck flexion and musculoskeletal pain in the neck region, half of the participants reported cervical pain. Of those who reported cervical pain (n=12) there were nine participants who had a neck flexion measurement that was compromised and three that were harmful. Another large percentage of 63% (n=15) reported shoulder/trapezius pain with nine compromised and six with a harmful degree of neck flexion. Cervical and shoulder/trapezius were the two most common areas of the body that participants reported to have their pain or problems.

The previously mentioned study by Morse et., al, concluded that of the 27 dental hygiene students who were investigated in the study, with a mean age of 24, 79% reported that were found working with a bent neck often or very often. Similar to this study, the Morse study reported one-hundred percent of the participants were found working with a neck bend forward.[15]

All twenty-four participants reported wearing dental loupes when performing manual scaling on patients. Dental loupes are magnification lenses that are an intervention to help decrease neck flexion. Literature states that neck pain is a natural consequence of forward neck flexion over prolonged periods of time. Loupes should allow the dental hygienists to magnify their working area without putting neck flexion and stress on themselves.[22] As the article by Garcia et., al, suggested, dental hygiene students should implement dental loupes in pre-clinical work to help with posture and vision clarity.[11] In this study, all participants wore loupes, but musculoskeletal pain was still present.

A factor that could affect the amount of poor posture is inadequately-fitted loupes. Dental loupes have three variables to assess when being fitted: working distance, declination angle, and the frame size. It is possible that the working distance can be measured too close, the declination angle not steep enough, or the frame size being too small which limits the space the microscopes can be placed thus effecting the declination angle. With all of these variables measured correctly, a dental professional should be able to flex their neck at 20° or less and ultimately improve postures that can contribute to MSDs.[18] These variables should be performed correctly by those fitting the loupes on dental providers, but it is possible that they are not, and dental hygiene students may not be able to interpret if they were measured incorrectly for dental loupes.

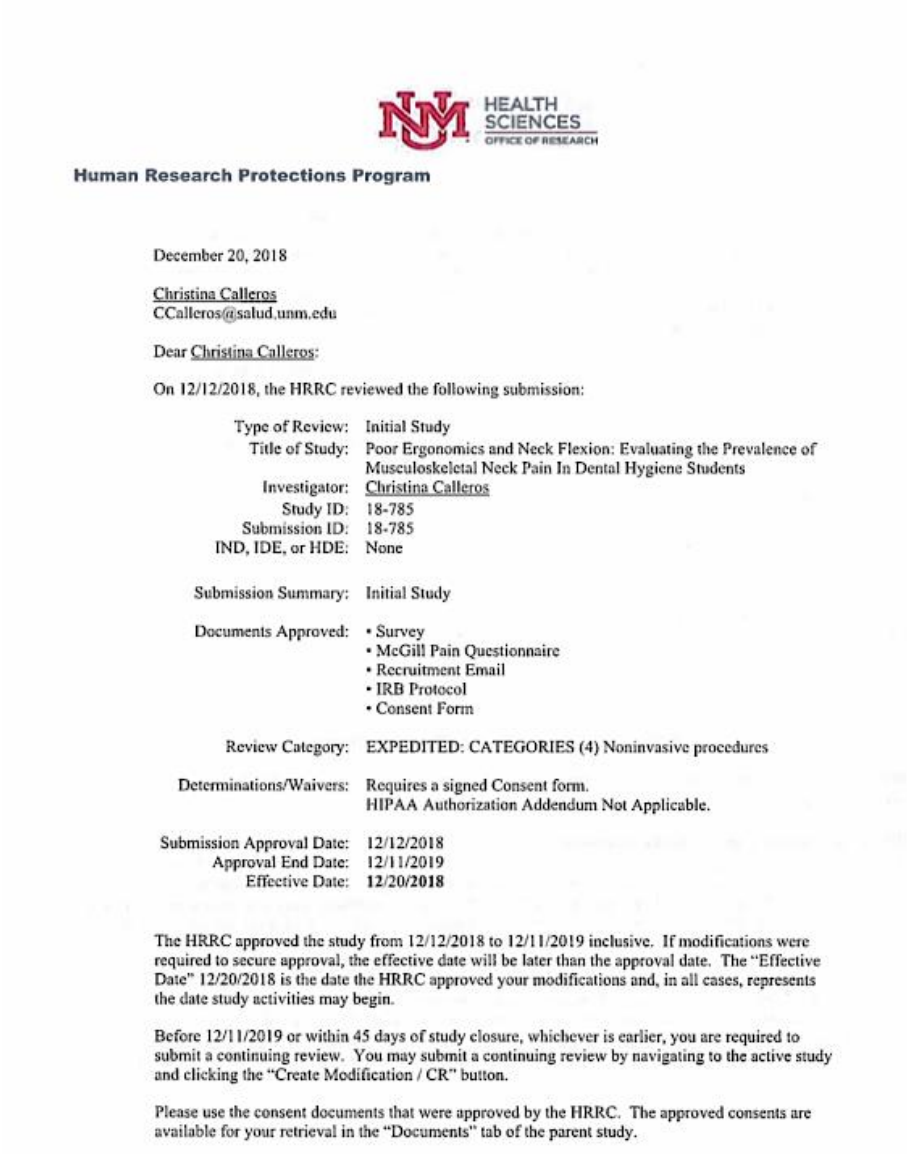
Conclusion:

Failure to maintain proper ergonomic operator positioning, specifically neck flexion ≤20°, during a manual scaling procedure in early dental hygiene education was supported by 50% (n=12) of participants who reported cervical pain or problems. The top five selected areas to have pain or problems were shoulder/trapezius, cervical, low back, scapular, and mid back. All participants had a neck flexion measurement over the recommended healthy degrees of ≤20°. The most reported region to have pain or problems was the shoulder/trapezius region. All participants reported wearing dental loupes during manual scaling procedures. Literature has already suggested these be worn to help with posture and clarity and therefore other variables to manage these issues should be questioned.

APPENDICES

APPENDIX A:

HRPP Approval Letter



HEALTH SCIENCES
OFFICE OF RESEARCH

Human Research Protections Program

December 20, 2018

Christina Calleros
CCalleros@salud.unm.edu

Dear Christina Calleros:

On 12/12/2018, the HRRC reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Poor Ergonomics and Neck Flexion: Evaluating the Prevalence of Musculoskeletal Neck Pain In Dental Hygiene Students
Investigator:	Christina Calleros
Study ID:	18-785
Submission ID:	18-785
IND, IDE, or HDE:	None
Submission Summary:	Initial Study
Documents Approved:	• Survey • McGill Pain Questionnaire • Recruitment Email • IRB Protocol • Consent Form
Review Category:	EXPEDITED: CATEGORIES (4) Noninvasive procedures
Determinations/Waivers:	Requires a signed Consent form. HIPAA Authorization Addendum Not Applicable.
Submission Approval Date:	12/12/2018
Approval End Date:	12/11/2019
Effective Date:	**12/20/2018**

The HRRC approved the study from 12/12/2018 to 12/11/2019 inclusive. If modifications were required to secure approval, the effective date will be later than the approval date. The "Effective Date" 12/20/2018 is the date the HRRC approved your modifications and, in all cases, represents the date study activities may begin.

Before 12/11/2019 or within 45 days of study closure, whichever is earlier, you are required to submit a continuing review. You may submit a continuing review by navigating to the active study and clicking the "Create Modification / CR" button.

Please use the consent documents that were approved by the HRRC. The approved consents are available for your retrieval in the "Documents" tab of the parent study.

HEALTH SCIENCES
OFFICE OF RESEARCH

This determination applies only to the activities described in this submission and does not apply should you make any changes to these documents. If changes are being considered these must be submitted for review in a study modification to the HRRC for a determination prior to implementation. If there are questions about whether HRRC review is needed, contact the HRPO before implementing changes without approval. A change in the research may disqualify this research from the current review category. You can create a modification by clicking Create Modification / CR within the study.

If your submission indicates you will translate materials post-approval of English materials, you may not recruit or enroll participants in another language, until all translated materials are reviewed and approved.

In conducting this study, you are required to follow the Investigator Manual dated April 1, 2015 (HRP-103), which can be found by navigating to the IRB Library.

Sincerely,

Walter Dehority, M.D.

Walter Dehority, MD
HRRC Chair

APPENDIX B:

Informed Consent

The University of New Mexico Health Sciences Center
Consent to Participate in Research

Poor Ergonomics and Neck Flexion: Evaluating the Prevalence of Musculoskeletal Neck Pain in Dental Hygiene Students

November 28, 2018

Purpose and General Information
You are being asked to participate in a research study that is being done by Christina Calleros, RDH, MS, who is the Principal Investigator, and Justine Stambaugh, RDH, BS, who is the co-investigator. This research is being done to evaluate poor ergonomics of dental hygiene students and to see if there is any associated pain. You are being asked to participate because the studies target population is dental hygiene students from the University of New Mexico. Approximately 24 people will take part in this study at the University of New Mexico.

This form will explain the study to you, including the possible risks as well as the possible benefits of participating. This is so you can make an informed choice about whether or not to participate in this study. Please read this Consent Form carefully. Ask the investigators or study staff to explain any words or information that you do not clearly understand.

What will happen if I participate?
If you agree to be in this study, you will be asked to read and sign this Consent Form. After you sign the Consent Form, the following things will happen: Upon return of the consent form to Christina Calleros, PI, or Justine Stambaugh, co-investigator, you will be given a study number. During anytime of the study period your ergonomics will be evaluated during your normal educational clinic hours at the University of New Mexico's Novitski Dental Hygiene Clinic. Your neck ergonomics will be evaluated by a Goniometer Application, G-Pro app, with an iPhone 8 plus that will measure your neck bend. You will continue your usual activities during the clinical setting with your patient. Your participation involves me, the co-investigator entering into the operatory briefly to examine your ergonomics with the G-pro app. After your ergonomics has been evaluated you will be asked to answer a pain questionnaire and a survey briefly totaling 5-10 minutes.

Participation in this study will take a total of 30 minutes over a period of 5 weeks.

What are the possible risks or discomforts of being in this study?
There are little to no foreseeable risks or inconvenience to participants in this study. No personal or health identifiers will be gathered from participants.

How will my information be kept confidential?
Your name and other identifying information will be maintained in locked files, available only to authorized members of the research team. Any personal identifying information and any record linking that

information to study ID numbers will be destroyed after 3 years per institutional protocol. Information resulting from this study will be used for research purposes and may be published; however, you will not be identified by name in any publications.

What are the benefits to being in this study?
There may or may not be direct benefit to you from being in this study. However, your participation may help find out if dental hygiene students during early education are at risk for musculoskeletal disorders.

What other choices do I have if I don't participate?
Taking part in this study is voluntary so you can choose not to participate or disenroll at any time.

What will happen if I am injured or become sick because I took part in this study?
If you are injured or become sick as a result of this study, UNMHSC will provide you with emergency treatment, at your cost.

No commitment is made by the University of New Mexico Health Sciences Center (UNMHSC) to provide free medical care or money for injuries to participants in this study.

In the event that you have an injury or illness that is caused by your participation in this study, reimbursement for all related costs of care will be sought from your insurer, managed care plan, or other benefits program. If you do not have insurance, you may be responsible for these costs. You will also be responsible for any associated co-payments or deductibles required by your insurance.

It is important for you to tell the investigator immediately if you have been injured or become sick because of taking part in this study. If you have any questions about these issues, or believe that you have been treated carelessly in the study, please contact the Human Research Review Committee (HRRC) at the (505) 272-1129 for more information.

How will I know if you learn something new that may change my mind about participating?
You will be informed of any significant new findings that become available during the course of the study, such as changes in the risks or benefits resulting from participating in the research or new alternatives to participation that might change your mind about participating.

Can I stop being in the study once I begin?
Yes. You can withdraw from this study at any time without affecting your participation in the program or access to your education.

The investigators have the right to end your participation in this study if they determine that you no longer qualify to take part, if you do not follow study procedures, or if it is in your best interest or the study's best interest to stop your participation.

What if I have questions or complaints about this study?
If you have any questions, concerns or complaints at any time about the research study, Christina Calleros, RDH, MS, Associate Professor at UNM will be glad to answer them at (505) 272-4513. If you would like to speak with someone other than the research team, you may call the Human Research Review Committee

(HRRC) at (505) 272-1129. The HRRC is a group of people from UNMHSC and the community who provide independent oversight of safety and ethical issues related to research involving human participants.

What are my rights as a research participant?
If you have questions regarding your rights as a research participant, you may call the Human Research Protections Office (HRPO) at (505) 272-1129 or visit the HRPO website at http://hsc.unm.edu/som/research/hrrc/.

Consent and Authorization

You are making a decision whether to participate in this study. Your signature below indicates that you read the information provided (or the information was read to you). By signing this Consent Form, you are not waiving any of your legal rights as a research participant.

I have had an opportunity to ask questions and all questions have been answered to my satisfaction. By signing this Consent Form, I agree to participate in this study and give permission for my health information to be used or disclosed as described in this Consent Form. A copy of this Consent Form will be provided to me.

_____	_____ / _____
Name of Adult Participant (print)	Signature of Adult Participant Date

I have explained the research to the participant and answered all of his/her questions. I believe that he/she understands the information in this consent form and freely consents to participate.

_____	_____ / _____
Name of Research Team Member	Signature of Research Team Member Date

APPENDIX C:

Recruitment Email

Dear Seniors,

I, Justine Stambaugh, in collaboration with my thesis committee, is conducting research of second year dental hygiene students at the University of New Mexico in poor ergonomics and neck flexion. You are receiving this email because you are enrolled into the dental hygiene program at UNM and are in your second year. The aim of this study is to determine that in early education, if dental hygiene students are experiencing neck pain and its association to poor ergonomics during manual scaling procedures.

If you agree to participate in this study, it will involve evaluating you during regular clinical activities at UNM during a clinical session. There will be no inconveniences to you as a participant and you are to continue activities as usual. After evaluating you during a clinical session you will be asked to fill out a short form McGill pain questionnaire by paper handout the same day you were evaluated. In addition to this questionnaire there will be a few yes or no questions for you to answer.

You do not have to participate in this study and your decision to participate is voluntary. If you feel you would like to participate in this study please print the consent form that is attached, sign and return to Christina Calleros or myself within one week of this email.

If you have any questions please contact:
Principal Investigator:
Christina Calleros RDH, MS Associate Professor
Department of Dental Hygiene
Business (505) 272-4513
CCalleros@salud.unm.edu

HRRC #18-785 Version Date:11/28/18

APPENDIX D:

McGill Pain Questionnaire

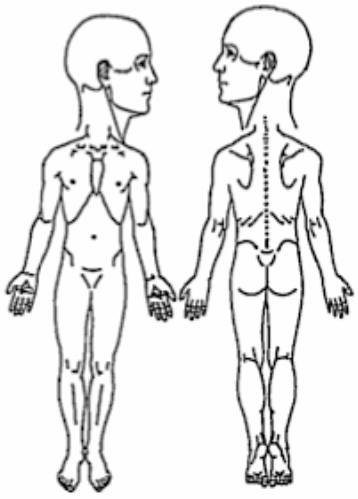
SHORT FORM McGILL PAIN QUESTIONNAIRE and PAIN DIAGRAM

Study #: _____

Date: _____

Check the column to indicate the level of your pain for each word or leave blank if it does not apply to you.

#	Mild	Moderate	Severe
1 Throbbing			
2 Shooting			
3 Stabbing			
4 Sharp			
5 Cramping			
6 Gnawing			
7 Hot-Burning			
8 Aching			
9 Heavy			
10 Tender			
11 Splitting			
12 Tiring-Exhausting			
13 Sickening			
14 Fearful			
15 Cruel-Punishing			



Mark or comment on the above figure where you have your pain or problems.

- Indicate on this line how bad your pain is—at the left end of line means no pain at all, at right end means worst pain possible.

No Pain _____ Worst Possible Pain

APPENDIX E:

Additional Survey

Study #:_____ Date:_____

Age:_____ Sex:_____

Instructions: Please circle either "yes" or "no" to the following questions.

1. Do you wear dental loupes when performing manual scaling during patient care?

   Yes
   No

2. Have you had an injury to the head, shoulder, or neck region prior to dental hygiene school?

   Yes
   No

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