INVESTIGATION INTO THE RELATIONSHIP BETWEEN POSTURE AND PSYCHOLOGY: THE PSYCHOLOGICAL RAMIFICATIONS OF FORWARD HEAD AND ROUNDED SHOULDER POSTURE.

by

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DISSERTATION

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ABSTRACT

INVESTIGATION INTO THE RELATIONSHIP BETWEEN POSTURE AND PSYCHOLOGY: THE PSYCHOLOGICAL RAMIFICATIONS OF FORWARD HEAD AND ROUNDED SHOULDER POSTURE.

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Embodied cognition speaks to the notion that the mind and body are inherently linked, and directly influence one another. Nonverbal communication experts hold the thought that sustaining chronic postures can impact an individual's psychological disposition and vice versa. Therefore, the potential to intervene on these postures from a musculoskeletal rehabilitation perspective provides the opportunity to improve not only an individual's posture, but also their psychological state.

Forward head posture (FHP) and rounded shoulder posture (RSP) are common postural adaptations that occur from musculoskeletal dysfunction, and often lead

to acute and chronic changes that can be a precursor to etiological pathologies. Although these have traditionally been thought of as a musculoskeletal problem by healthcare practitioners, nonverbal communication and psychology literature explain that these two postures are indicative of specific psychological dispositions.

Nonverbal communication literature speaks to these two postures as denoting submissiveness in individuals. Specifically, characteristics of FHP and RSP are linked to anxiety, depression, and sadness which can cause changes in muscle tonicity, gait, emotional states, and cognitive processing. Therefore, understanding the link between postural abnormalities and an individual's mindset could provide the foundation for specific posture-based rehabilitation to alleviate the negative psychological impacts posture has.

Study 1 (Chapter 2) identifies the need for postural improvement in college-aged populations. One hundred and sixty-one participants aged 19-26 completed a survey asking self-reported ratings of posture, their desires to improve posture, their levels of knowledge about postural rehabilitation techniques, and their current level of neck disability. Eighty-nine percent of participants wished their posture was better, 94% and 96% identified the need to improve their sitting and standing posture, respectively, and 35% were classified as having mild or moderate disability according to the Neck Disability Index. Amongst the rehabilitation techniques, the more integrative modalities such as the Feldenkrais and Alexander methods, only were familiar to 3.1% of the participants.

Previous literature demonstrated a variety of neck strengthening programs were successful in improving postural measures. However, in exploring different exercise techniques, a distinct lack of neuromuscular integration (NI) techniques was evident. Therefore, a review was necessary. Study 2 (Chapter 3) encompasses a systematic review of the various studies that utilized a NI approach to the rehabilitation of both FHP and RSP. Only 6 articles were identified within the specified range - 4 for FHP and 2 for RSP. 184 articles were excluded from the analysis, and the review highlighted the need for more NI-based studies dedicated to the rehabilitation of upper body postural dysfunctions to be explored.

Study 3 (Chapter 4) compares the psychological measures between individuals with FHP and without FHP as measured by a myriad of patient-rated outcome scores. One hundred and twenty-one healthy, college-aged students were split into bad posture (n=65) and good posture (n=56) groups using a craniovertebral angle (CVA) measurement of ≤50º denoting FHP. Significant differences between groups were seen for Neck Disability Index (NDI) and the PROMIS-29 scales for measures of anxiety, fatigue, sleep disturbance, and satisfaction with social role – all of which had small to moderate effect sizes according to the Cohen's d metric. This study provided the rationale that there are distinct differences between psychological measures in healthy college-aged students for those with and without FHP.

Finally, Study 4 (Chapter 5) investigated the effect of correcting FHP using a NI rehabilitation technique versus general exercise or no exercise. Baseline measures were obtained for CVA, scapular index, shoulder range of motion, deep cervical flexor endurance, and psychological measures: Neck Disability Index (NDI), General Anxiety Disorder – 7 (GAD-7), Dispositional Positive Emotion Scale – Pride (DPES), and the Patient Rated Outcome Measurement Information System – 29 (PROMIS-29). Participants were randomly assigned to one of three treatments: intervention (NI rehabilitation), general exercise, and a control group. Follow-up assessments were collected after 9 weeks. The only significant improvement was associated with the intervention group for CVA, however overall, the intervention group demonstrated more consistent improvement in the variables measured than the general exercise or the control.

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DEDICATION

This work is dedicated to the best family I could ever ask for. My parents, Kim and Trevor, and my sisters, Shelly, Angela, and Sarah - thank you for always supporting my dream regardless of the sacrifices. Your constant support and encouragement were always a phone call away. And, of course, to Clinique, you motivate and push me each day to be better, I thank you for your constant encouragement and patience.

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CHAPTER 1

INTRODUCTION

Posture

The position of your body while standing, sitting, or lying down is commonly defined as a person's posture. Although the 21st century has brought more attention to posture within social and economic circles through the advertisement of various products from standing desks to wearable posture sensors, posture and good health have been linked for centuries.[1] In fact, illness was often linked to the occupational hazard of sitting too much and bending over to read and write.[1]

The physical stresses or the lack of physical stresses placed on the body over the course of a day with both static and dynamic positions will typically determine one's body position or posture. Musculoskeletal tissue responds to mechanical stimuli, and this response results in a biological response through a process known as mechanotransduction, which is integral in a tissue's ability to adapt to a dynamic environment.[2] Mechanotransduction involves the conversion of mechanical stimuli into biochemical signals.[3] As a result there may be intracellular changes, like ion concentrations and neural activation that can result in either muscle tonus or muscle flaccidity. Muscles are highly sensitive to their mechanical environment and alterations in frequency, duration, and intensity of mechanical load will affect muscle function, leading to adaptations that reflect those stressors. Ultimately, as these muscle tissue responses increase in intensity, duration, and/or frequency, compensatory patterns will likely occur which can lead to postural adaptations.[3] Ideal posture is defined as "a musculoskeletal balance which involves a minimal amount of stress and strain on the body".[4] Postural adaptations by the body's musculoskeletal system are made based on habitual movements and chronic body alignments which alter the way individuals move and function. Sitting and reading bent over are habitual movements that can lead to postural adaptations including a forward head or rounded shoulder posture. These maladaptations can lead to compensation or pain patterns which can have chronic musuculoskeletal implications that impact function and quality of life.[5]

Forward Head and Rounded Shoulder Posture Prevalence and Epidemiology

Postural adaptations by the body's musculoskeletal system are made based on habitual movements and chronic body alignments which alter the way individuals move and function. These maladaptations can lead to compensation or pain patterns which can have chronic musuculoskeletal implications that impact function and quality of life. Two postures of significant concern are that of forward head posture (FHP) and rounded shoulder posture (RSP).

Forward head posture (FHP) is characterized by an anterior protrusion of the head in the sagittal plane, coupled with excess cervical extension, with a population prevalence estimated to be from 61-85% of individuals.[6-10] Similarly, rounded shoulder posture (RSP) impacts 66% to 78% of individuals[6,8,10] and is typified by an anterior rolling of the shoulders, coupled with glenohumeral internal rotation, and thoracic kyphosis. Both FHP and RSP have a varying array of etiological complications which contribute to pain and dysfunction for an effected individual. Although these postural presentations can present in isolation,[11] they can also occur in conjunction with one another[12-18] – Dr. Vladamir Janda coined this dual presentation 'upper cross syndrome (UCS).[19]

Earning the title as the 'father of rehabilitation',[19,20] Dr. Vladamir Janda was a prominent clinician, educator, and researcher who's perspective on rehabilitation shapes the current methods used today. Dr. Janda developed a nomenclature term known as UCS to describe the presentation of tightness and weakness commonly coupled in a clinical evaluation. Specifically, if a lateral image of an individual was taken, a *cross* would be imagined bisecting the shoulder girdle, both at 45° angles – the line over the pectoralis and upper trapezius would represent tightness, while the other line represented weakness over the lower trapezius and deep cervical flexors. UCS creates dysfunction primarily at the atlanto-occipital joint, cervicothoracic joint, and glenohumeral joint.[19] This presentation underpins the link between FHP and RSP as the muscle hyper- and hypo-tonicity presentations often mimic the foundational work of Dr. Janda and UCS. Together these postures have a multitude of negative effects on health, physical functioning and psychological disposition and, due to their high prevalence in modern society, further exploration is needed.

Forward Head Posture (FHP)

FHP is caused by hypotonicity (or underactivity) of the deep cervical flexors, scapular retractors and depressors, and hypertonicity (overactivity) of the cervical extensors and scapular elevators and protractors. These deep cervical flexors consist of the longus colli, longus capitis, longus cervicis, and the rectus capitis anterior and lateralis. Together these muscles create flexion at the cervical spine and atlanto-occipital joint,[21-25] and work to resist the extension force during activation of the levator scapulae and upper trapezius during scapula upward rotation and elevation.[22] The muscles that become overactive to compensate for underactivity in the deep cervical flexors are the sternocleidomastoid (SCM), anterior and middle scalenes compensating to create cervical flexion,[21,26,27] along with upper trapezius and levator scapulae. [14,19,28,29]

This posture is commonly seen in office workers and has been attributed to increased smartphone use[30-34] also – coining the colloquial term of "text neck".[35,36] This increased forward protrusion of the head decreases the lordosis of the cervical spine and increases the thoracic kyphosis of an individual in order to maintain balance. These compensations lead to an increase in FHP and subsequent decrease in craniovertebral angle (CVA).

FHP has been traditionally measured by what's known as craniovertebral angle (CVA), which uses a lateral photograph of an individual to get their side profile. The image is then analyzed with a vertical and horizontal line through the C7 vertebrae, followed by an angle measurement from this C7 intersection to the tragus of the ear. This measurement technique is widely used in FHP studies and has been shown to be valid and reliable[37,38] – it is considered the gold standard of FHP measurement.

Studies have been done to examine the severity of FHP and the implications it has on weight distribution of the head and, therefore, strain on the neck musculature. Hansraj [39] found that as degree of forward tilt of the head increases, the relative weight of the head increases too. At neutral (0°) it would weigh 10-12lbs, at 15° this load increases to 27lbs, 30° of tilt it is 40lbs, and at 60° it equates to 60lbs of force to the cervical spine. These findings highlight the importance of proper posture and ergonomic set up for symptomatic and asymptomatic patients alike.

FHP has been shown to be etiologically associated with pathologies including temporomandibular joint dysfunction syndrome,[40-42] thoracic outlet syndrome,[43] thoracic kyphosis,[18] carpal tunnel syndrome,[44] cervicogenic headaches,[45] cervical and lumbosacral radiculopathy,[46,47] and chronic neck pain.[10,11,48-50] TMJD in particular can cause structural changes to the mandible with the condyle moving posteriorly in FHP patients.[51]

Pertaining to daily function, FHP has demonstrated negative correlations with body mass index (BMI) in adult women,[52] balance and proprioception,[53-56] ankle dorsiflexion,[57] and alterations in neck muscle activation patterns,[27,58,59] and cervical range of motion and strength.[18,45,48,60-63] Physiologically, FHP is also a factor affecting respiratory function in measures such as forced vital capacity, forced expiratory volume at 1 second (FEV1), peak expiratory flow (PEF).[16,32,64-71]

FHP interventions using home-based exercise programmes[72], pilates-based workouts,[73] scapular stabilization exercises,[74] core stability and functional corrective exercises,[75,76] which all focus on strengthening the aforementioned weak musculature, have led to improvements in posture and postural symptoms. Therapeutic exercise was designated a 1a level of evidence according to a systematic review performed by Sheikhhoseini et al. [77].

Rounded Shoulder Posture (RSP)

RSP is caused by overactivity in the muscles responsible for humeral internal rotation, and scapular elevation and anterior tipping: the pectoralis major, pectoralis minor, latissimus dorsi, subscapular, levator scapulae, and upper trapezius.[11,19,62,78-84] While underactivity is seen in the infraspinatus, teres minor, posterior deltoid, lower and middle trapezius, and the serratus anterior muscles[71,80,83-87] which are responsible for humeral external rotation, scapular depression and posterior tipping.

Unlike FHP, measurement of RSP has no gold standard and each purported measurement technique has its own limitations. Harrison et al. [88] examined a variety of measurement techniques for shoulder posture using a trisquare to measure linear distances to various anatomical landmarks. The trisquare measurement technique requires the subject to stand close to a wall or firm surface to measure these distances, thereby inherently creating an external cue for participants. Additionally, it does not account for postural sway of an individual. For example, if a subject had a natural inclination to have a forward lean starting at the ankle joint, all linear distances from the wall would vary increasingly as measurements progressed up the body. In this instance, someone who displayed a forward lean would also have a larger linear distance at the shoulder height due to this bias in the lower segment of the body.

Borstad [86] examined four measurement techniques that have been used to measure RSP: Kendall measurement technique, Thoracic Kyphosis Index (TKI), Pectoralis Minor Index (PMI), and Scapula Index (SI). Firstly, the Kendall technique had subjects lying supine on a treatment table and a plastic ruler was used to measure the distance between the posterolateral acromion (PLA) and the treatment table. This technique provides a measurement for the subject's posture in a supine setting which involves a gravity resisted state, as well as not functionally representing a RSP state. The TKI is used to quantify the curve of the thoracic spine and involves measurement of the distance between the T1 and T12 vertebrae using a flexible ruler[89]. Although thoracic kyphosis has been associated with shoulder posture, it lacks plausibility as an accurate measurement of RSP.[17] The PMI is an equation used to measure the pectoralis minor length divided by height, and the resultant answer is multiplied by 100. Borstad [86] showed no association between these measures and SI.

Finally, the SI uses a tape measure to calculate the distance between anatomical landmarks on the anterior and posterior surfaces of a standing subject's body. Anteriorly, a distance is measured between the midpoint of the sternal notch and the medial most aspect of the coracoid process. Posteriorly, measurement is made between the C7 vertebrae and PLA. The anterior measurement is divided by the posterior measurement, and the resultant answer multiplied by 100. Borstad [86] found this method to be statistically significant when comparing to the pectoralis minor lengths of cadaver models which were used to validate RSP measurement techniques. Furthermore, this measurement incorporates the shoulder complex into the final measurement. This method has since been used and shown to have high intrarater and interrater reliability (0.77 and 0.72 respectively).[90-92] The SI technique has been correlated with cadaver measurement studies of pectoralis minor length to show that the SI is a plausible measure of RSP.[92,93]

Postural dysfunction in the shoulder resulting from RSP can increase the potential for pathological conditions such as subacromial impingement,[80,94,95] glenohumeral instability,[96,97] rotator cuff and range of motion issues,[18,98,99] thoracic outlet syndrome,[43,100-102] and abnormal scapulohumeral rhythm due to alterations in muscle activation patterns, namely the serratus anterior and lower trapezius.[80,82,99,103]

Immediate positive results from RSP interventions have been reported as demonstrated by Birinci et al. [68] who investigated the effect of a single session of manual therapy and stretching techniques on the pectoralis minor muscle. Participants were blinded and assigned to one of 4 groups – proprioceptive neuromuscular facilitation stretching (PNF), static stretching, myofascial release, and control. Improvements in pectoralis minor length and index were seen in groups who performed PNF stretching and myofascial release, and these improvements remained statistically significant 24-hours post-intervention.

Longer interventions have been conducted such as the 8-week exercise intervention study done by Lynch et al. [62] Stretching and strengthening exercises were performed 3 times per week and focused on strengthening of the periscapular muscles and improving the flexibility of the pectoralis minor and cervical neck extensors. Improvements were seen in RSP as measured by the forward shoulder translation technique which has subjects stand in front of a wall while the distance from posterior lateral acromion to wall is measured. Despite inconsistency in the measurement of RSP as discussed earlier, the improvements in RSP were statistically significant for the intervention group. Similar studies by Roddey et al. [104] and Kluemper et al. [105] highlight the efficacy of longer exercise interventions, and also interventions focused on stretching and strengthening the affected muscles.

Together, FHP and RSP have muscle tonicity commonalities which led Dr. Janda to coin the term UCS.[19] Multiple studies have confirmed that FHP and RSP often co-exist together and the two have demonstrated mild to strong correlations.[15,17,106] Do Youn Lee et al. [90] saw both FHP and RSP measures improve with the implementation of FHP specific exercises and Fathollahnejad et al. [107] also saw concurrent improvements in these postures with the delivery of a single exercise regime. Pain patterns in contributing muscles such as the upper trapezius have been shown to serve as predictor variables for alterations in muscle activation patterns commonly seen in FHP and RSP.[98,108,109]

The above synopsis has demonstrated the nature and musculoskeletal implications of postural dysfunction, but researchers in this field have failed to acknowledge the potential psychological and nonverbal communication ramifications associated with chronic postures. Linking the findings from the rehabilitation and injury incidence realm, with the work of social sciences provides a novel perspective on how healthcare professionals view chronic postural adaptations.

Relationship between Posture and Nonverbal Communication

Charles Darwin, in *The Expression of Emotions in Man and Animals (1872/1998),* recorded his observations about displays of emotion in the bodies of mammals. This seminal work holds that expressions shown in the face and body posture are rooted in both humans and animals. For many years, Darwin observed, recorded, and collected evidence of living creatures during the years traveling aboard *The Beagle*. Together with his studied visits to the London Zoo as a parent of a young infant, Darwin found that even in isolation from other similar beings, animals and humans displayed common expressions of emotion. This he framed as the *continuity of man and animals*. This publication provoked considerable controversy as previously, the emotional expression displayed by humans was believed to be exclusive to them. Specifically, Darwin found that the posturing between man and animals shows similarities in displays of dominance and submission with dogs, for example, who stand erect and raise their hair to appear as domineering as possible. The same holds true with displays of submission, during which a dog attempts to appear smaller – a trait also common to humans. Darwin and Prodger [110] called this principal the *direct action of the nervous system* whereby certain actions are independent from conscious will and instead are shown as a response to the presence of specific emotions. Darwin further advanced the contention that not only do animals and humans have similar emotional expressions, all humans have universally common traits of emotions and their displays. This was an especially provocative claim in that era because of its suggestion that all humans held common ancestry.

Nonverbal communication research, specifically considering the communicative function of nonverbal displays such as expressions in the face, body, postures, gestures, and eye gaze, began to emerge many decades later based on Darwin's earlier observations. The groundbreaking work of psychologist Paul Ekman in 1979 revealed six facial expressions as true indicators of emotion irrespective of culture – anger, disgust, happiness, sadness, fear, and surprise. An additional emotion, pride, was added to the original six by Jessica L. Tracy in 2008. Pride presents with an expanded posture, head tilted back, and a low intensity smile.[111] This was further expanded upon by her work with David Matsumoto on sighted, blind, and congenitally blind Olympic-level athletes who all showed similar reactions to failure and success with their depictions of shame and pride respectively.[112]

Anthropologist Ray Birdwhistell took a different approach to Ekman and founded what we now know as kinesics – the study of human movement as patterned visual communication.[113,114] Birdwhistell argued that body movements were socially learned and, thus, more culturally patterned as opposed to universal in nature. These competing positions ultimately divided the nonverbal scholarly work of Birdwhistell and the renowned anthropologist Margaret Mead, when subsequent research drew on Ekman's line of study grounded in Darwin's work on the universality of expressions of emotion in humans.

Later, Dr. Judee Burgoon [115] detailed the importance and social significance, and its relationship to dominance and power, through her investigation of the works of Darwin (1872/1998), Sigmund Freud (early 1900s), and Ray Birdwhistell (1970s).[114] By encompassing the fields of psychology, nonverbal communication, and anthropology, Burgoon found that power, dominance, and status are best thought of as interrelated attributes. Drawing on her seminal work on the dynamics of dominance-submission and power-powerlessness, Burgoon noted that she shares the sentiment by Hall et al. [116] that such displays integrate culture, context, social, and relational motives.

Mehrabian [117] demonstrated that submission and subordination can be shown through aspects such as stooped and contractive postures, drawing the head into the shoulders, and retreating body orientations. These displays are similar to Darwin's much earlier belief that submissive postures in animals, specifically dogs, is an attempt to look smaller. Conversely, dominance has been shown through erect postures, firm stances, wide and animated gesturing, and more expansive gestures with the hands away from the body.[118] Gifford [119] confirmed this by reporting similar behaviors for perceptions of dominant-ambitious individuals who displayed a lack of forward head tilt, less arm wrap, more gestures, and more direct body orientation when compared to submissive individuals.

This notion that the mind and body are inherently connected is referred to as embodied cognition.[120-122] Various emotional states have been linked to changes in posture whether that change be chronic or temporary. Typically, sadness and depression has been linked to a more stooped posture which includes increased thoracic kyphosis and forward head protrusion when compared to healthy controls,[123-126] and a change in gait related to stride length, arm swing, and a stooping posture.[127-129] On a musculoskeletal level, negative emotions such as stress, anxiety, depression, or fear have been shown to produce muscle tonicity changes and impact co-contractions.[130-137]

Short-term changes in posture have also been linked to mood state. The chest heights of both children and adults were shown to be higher while walking or sitting when imagining positive emotions compared to negative emotions.[138,139] Temporary holdings of stooped postures results in individuals less persistent in difficult tasks,[140] having lower self-evaluated confidence,[141] changing self-reports of emotion and memory recall,[142] and experiencing increased stress and decreased creativity.[143]

Examining FHP and RSP as mentioned above, more recent research has produced noteworthy findings relating to human emotion and social perception. Mark Coulson [144] demonstrated, through the use of computer-generated mannequin figures, that differences in postural displays can be congruent with various emotions. The six emotions investigated were anger, disgust, fear, happiness, sadness, and surprise, and the RSP and FHP had a 95% identification congruence with ‘sadness’ amongst the 61 research participants. Coulson also noted that perception of sadness was the only posture that contained a forward protruding head posture, which correlates with the findings of Gifford [119].

Examining RSP and FHP specifically, Ramezanzade and Arabnarmi [91] found a negative correlation between self-esteem and scapular index (a measure of RSP), showing that self-esteem decreases as scapular index measures increase, and vice versa. Similarly, Canales et al. [145] found that both RSP and FHP were greater in recurrent depressive episodes in 136 patients aged 18-60 years. Confirmation of this finding was also found in studies examining 346 elementary students[146] and in women aged 20-30 years.[123] Findings linking thoracic kyphosis to various traits such as anxiety, depression, and aggression have also been found to be significant.[147,148]

Therefore, there is significant evidence that a physical posture caused by musculoskeletal imbalance, like FHP or RSP, is linked to psychological disposition. Because physical rehabilitation is designed to correct musculoskeletal imbalances, it is important to explore the use of exercises and rehabilitation techniques for the correction of altered postures like FHP and RSP and thereby investigate the likelihood that physical postural corrections may improve mood and emotion. Often times, rehabilitation approaches have focused on isolated treatment principles that only feature exercises in one joint or plane of motion, but recent rehabilitation methodologies have favored a neuromuscular integration approach which focuses on incorporating the whole-body. Implementation of a neuromuscular integration approach for FHP and RSP would not only provide the rehabilitation philosophy needed to correct the postural presentation and alleviate its symptoms, but also address the wholistic complications that postural dysfunction could have that a traditional isolation approach would be unable to address. In turn, this rehabilitation approach could potentially alleviate psychological related symptoms in individuals suffering from FHP and RSP, leading to improved mood and emotional state.

Physical Rehabilitation - Neuromuscular Integration Approach

Traditional rehabilitation approaches have focused on FHP and RSP rehabilitation by treating the involved muscles in isolation – stretching the hypertonic muscles and strengthening the hypotonic muscles. An alternative approach would be to address the postural misalignments as consequences of the entire kinetic chain – understanding that dysfunction in the upper extremity can improve from interventions focused on a more holistic approach, which involve muscular strength, power, and activation patterns,[149] particularly in the frontal/coronal plane for the trunk and core.[150] This concept is often referred to as a neuromuscular integration approach. Learning to correctly activate requisite musculature, react to proprioceptive changes based upon the environment, and to stabilize body segments as they move, has been identified as a key component of neuromuscular integration and has been linked to the prevention, diagnosis, and treatment of lower extremity musculoskeletal injuries. Research has demonstrated that muscular recruitment patterns are altered post-lower extremity injury,[151,152] and adopting neuromuscular control exercises has grown in importance for successful rehabilitation outcomes. Neuromuscular control-based exercise protocols are now considered among the best practices for prevention of injuries such as knee anterior cruciate ligament (ACL) tears,[153-156] lateral ankle sprains,[157-160] and overall lower extremity injuries.[161-163]

Research has also shown that upper and lower body functioning are inextricably linked as work by Garrison et al. [164] showed reduced lower extremity balance in baseball athletes who suffered ulnar collateral ligament (UCL) tears in their elbow. Laudner et al. [165] showed pitchers with lower lumbopelvic control had more upper extremity injuries than those with greater lumbopelvic control,[166] Olivier et al. [167] found that the same holds true for pace bowlers in cricket, and lumbopelvic work is now the recommendation for overhead athletes to reduce injury risk and improve performance.[168] To further demonstrate the link between upper and lower extremity function, Moustafa and Diab [46] demonstrated alleviation of lumbosacral radiculopathy symptoms with the implementation of corrective exercises aimed to address FHP. And despite seeing no improvements in shoulder posture, Murta et al. [169] saw increased lower trapezius activity - a commonly underactive muscle in these postural dysfunctions – following holistic exercises, further highlighting the importance of wholistic rehabilitation approaches.

For the treatment of UCS, holistic exercise prescription methods have proven to be effective at providing alleviation of upper extremity postural dysfunction. Abdolahzad and Daneshmandi [170] implemented an 8-week corrective exercise program written by the National Academy of Sports Medicine (NASM) which involved whole-body exercises such as lunges and squats in addition to isolated exercises and saw improvements in FHP and RSP. This was later successfully repeated by Mohammad Jabbar and Gandomi [171] and Roshani et al. [172]. A systematic review of literature performed by Lauman and Anderson [173] demonstrated the efficacy of holistic exercise prescription for alleviation of FHP with inconclusive results for RSP, as a function of lack of research, heterogeneity of research, and lack of uniformity with the measurement technique used for RSP.

They concluded that more research needs to be done utilizing these rehabilitation principles.

Conclusion

The issues surrounding chronic postural ailments like FHP and RSP can lead to a myriad of physical, mental, and emotional ailments as evidenced by rehabilitation and musculoskeletal literature and historical writings. Although examining these dysfunctions through the lens of psychological and nonverbal communication literature has shown how these two postures may manifest into psychological issues that impact the way individuals view and are viewed by the world, there is little evidence on how addressing a dysfunctional physical posture with integrative rehabilitation may impact psychological health. Bridging the viewpoints of posture, emotion, and nonverbal communication together with neuromuscular integration exercise approaches, provides a novel and exciting take on the management of both a physical and emotional manifestation. Positive findings from rehabilitating FHP and RSP with integrative exercises could provide an impetus to use physical techniques to improve mental health outcomes, which then lays a foundation for future work on the use of physical rehabilitation in conjunction with other approaches for the management of a variety of specific mental health diagnoses.

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CHAPTER 2

IMPACTS AND ATTITUDES OF POSTURE ON DAILY FUNCTION, DISABILITY, AND PSYCHOLOGICAL MEASURES

Abstract

An exploratory survey was used to assess the self-reported prevalence of postural dysfunction, movement limitations, and knowledge of rehabilitation interventions among a healthy college-aged population. In this descriptive, observational survey study, 58 male and 103 female (n=161) college students aged 18-26 years (mean = 21.6±2.0y) were asked questions to assess their self-perceived attitudes regarding standing and sitting posture, ergonomics, neck disability (NDI), mental health outcomes, knowledge of postural rehabilitation techniques, and cervical and shoulder range of motion (ROM). In total, 89% of participants wished their posture was better, 94% and 96% believed their standing and sitting postures could be improved, respectively. Thirty-five percent of participants qualified as Mild or Moderate Disability based upon their cumulative NDI scores. There was a strong positive correlation (r=0.61) between participants' self-reported need to improve standing posture and sitting posture. Moderate correlations were calculated between pain when sitting and total NDI score (r=0.47). The findings from this study demonstrate the prevalence of posture-related issues and the ramifications in healthy college-aged populations, and the impact these issues have on daily function. Participants self-reported the need for postural improvement and reported pain patterns when sleeping and/or sitting, demonstrating that this age group has concerns and limitations related to posture. Future research should investigate the role of posture education, including postural restoration exercises in college-aged populations to alleviate early-onset neck pain and reduce the risk of developing future chronic neck pain.

Impact Statement

This study demonstrates the prevalence of poor posture amongst college-aged populations, and their self-perceived attitudes towards posture. Using various patient-rated outcome measures in conjunction with self-reported measures, this study provides support for findings within nonverbal communication literature demonstrating a link between poor body posture and psychological dispositions such as mood and confidence. Future research should investigate the impact of physical rehabilitation protocols aimed at improving posture and their potential effects on psychological outcome measures.

Introduction

College is a pivotal time for young individuals to position themselves for the future, as individuals that receive an undergraduate degree or higher will likely earn a median annual salary that is $20,000 higher than those with only some college or a high school diploma.[1] Therefore, maintaining optimal mental, emotional, social, and physical health during this period is of critical importance to maximize this opportunity. Improved mental health, increased physical activity, reduced pain and increased function related to activities of daily living including sitting and standing are examples of important health outcomes in this population.

Unfortunately, according to the American College of Health Association,[2] 27.4% and 21.7% of college students had been diagnosed with anxiety or depression, respectively. These findings are substantiated by independent studies that report from 20% to 36% of college-aged students are impacted by mental health issues[3-6] and over half of students were categorized as having poor sleep[7] or sleeping less than 8 hours per night.[8,9] The need for specific mental health intervention strategies in this population are imperative, and research has commonly cited physical activity as an effective intervention strategy.[10-14]

Correct sitting and standing posture are essential for all activities of daily living whether a person is at work, rest, or play. A person's posture has been linked to pain measures, quality of life, and mental health outcomes such as mood and confidence.[15-17] Forward head posture (FHP) is a common postural dysfunction caused by imbalances in the anterior and posterior musculature of the neck and upper shoulders. FHP affects the cervical spine and presents with a forward protrusion of the head. This postural malalignment is exacerbated by prolonged screen usage and has been linked with increases in mobile phone usage,[18-21] so it is known colloquially as text neck.[22] FHP is measured using the craniovertebral angle (CVA) technique, which measures the perpendicular angle from the seventh cervical vertebrae to the tragus of the ear with a still shot photograph. Mobile phone usage places the CVA at 33-45 degrees on average, which is considered as FHP.[20] FHP is estimated to be present in 61-85% of individuals.[23-27] This habitual posture increases the mechanical load on the neck, leading to general pain and dysfunction.[28-32] Unfortunately, FHP is a growing cause of pain and dysfunction among young adults[18,20,33,34] and can lead to a multitude of etiological complications such as temporomandibular joint dysfunction syndrome,[35-37] headaches,[38,39] and thoracic outlet syndrome,[40] and chronic neck pain.[27,41-43] Neck pain is the fourth largest cause of disability globally; [34] therefore addressing this issue is important – particularly with the fact that neck musculoskeletal disorders impact late adolescence at almost the same rate as adults.[44]

To our knowledge, no investigations have been done to examine the prevalence of posture, exercise, and psychological disposition in college-aged students. With nonverbal communication literature demonstrating a clear link between posture and psychology, the aim of this study was to perform an investigative survey on how posture affects daily living, neck disability, and mental health in a college-aged population. We hypothesized that there would be a statistical relationship between posture, neck disability, and psychological disposition. Whereby, those who report their posture as being poor or in need of improvement would report negative psychological outcomes as measured by the survey. This would demonstrate the importance of healthy lifestyle habits for this population, and provide the rationale for future research in this subset.

Methods

Recruitment and Data Collection

A self-reported exploratory survey was conducted during a 15-week spring semester. Participants across the United States were recruited via social media, printed flyers, in-person contact, and email distribution. Participants clicked a hyperlink or scanned a QR code to take the survey through their own personal devices (e.g., phone, laptop, tablet). Each survey was anonymous and completed through the secure online QuestionPro survey system. QuestionPro system ensures all data collected using the platform is fully compliant including data portability, data protection, consent and other compliance features according to General Data Protection Regulations (GDPR). QuestionPro meets globally recognized international standards for managing risks related to the data security. The average completion time for the 43 questions was 8 minutes. The study was approved by the Institutional Review Board at the university. Study participants electronically signed and agreed to an informed consent before completing the survey questions. Inclusion criteria were: college-aged students (18-26 years old), without current/acute upper extremity injury, no surgical history to the upper body, head, neck, back, or upper extremities. Exclusion criteria were: current/acute upper extremity injury, history of surgery to upper body, head, neck, back or upper extremities, history of cervical fractures, stenosis, or disc herniation, history of cervical or brachial nerve related injury, neurological symptoms to the upper limb, diagnosed musculoskeletal pathologies (acute or chronic) in the upper extremity, congenital defects, or inner ear issues/vertigo. This study was developed with an explorative aim to assess the psychological and physical effects of posture in college-aged populations. No power analysis was performed to determine sample size, instead, as many participants were gathered as possible. Only completed surveys were used in the subsequent statistical analysis.

Survey Instrument and Measures

Demographics.

The first survey section consisted of questions regarding demographic data (age, height, weight, sex, ethnicity) and physical activity level based upon the Tegner Activity Scale to gauge exercise participation levels of the participants. This activity questionnaire asked participants to rate their current levels of exercise from zero (avoiding exercise) to ten (running over 25 miles per week or comparable physical activity). Although the Tegner Activity Scale was initially developed for knee injury populations, the data collected provided general data related to self-reports of physical activity.

Self-Reported Assessment of Posture.

The second section consisted of six questions pertaining to posture and daily living that were written by the research personnel. Of these six questions, four of these were binary yes/no questions relating to feelings about posture and presence of pain. Asking participants ‘Do you wish your posture was better’ was aimed to identify the desire for posture improvement, while questions relating to upper body pain and ergonomics were used to identify the need for posture awareness. The remaining two questions asked participants to rate their standing and sitting postures from Very Poor (1) to Very Good (4). These questions were used to gauge an individual's ability to recognize their own postural deficiencies.

Patient Rated Outcomes.

The third section contained patient rated outcomes including the Neck Disability Index (NDI) and the Dispositional Positive Emotion Scale (DPES). The NDI is a ten-item questionnaire pertaining to daily living and functioning for neck pain and disability. Each question is ranked on 6-point scale from full-function to completely disabled as it pertains to that category. Scores are then cumulated, and participants are ranked into categories of disability from no disability to completely disabled. The NDI form has been shown to be a valid and reliable form used to assess neck pain and function in both non-specific and pathological neck disorders.[45,46] Psychological measures were the next topic measured, and these 5 questions were gathered from the DPES – specifically, the Pride subscale. These questions addressed many of psychological and nonverbal communication ramifications of poor head and shoulder posture that pertain to self-esteem, emotion, dominance, and submission.[15-17,47,48] The DPES-Pride subscale was chosen because the 5 questions utilized reflect findings about the nonverbal communication ramifications of FHP and RSP. These ramifications include the postures indicating submissiveness, lacking dominance, and attempts for an individual to appear smaller to decrease attention.[17,49] These questions are scored from 1 to 7 with higher numbers associated with stronger agreement to the asked statement. Scores are calculated and average over the 5 questions.

Rehabilitation Technique Knowledge.

The fifth section of rehabilitation techniques was used to determine the participant's knowledge on the various rehabilitation interventions used to treat postural dysfunction. Fifteen options were given that encompassed a variety of exercise, stretching, and manual therapy techniques commonly used to treat postural dysfunction. Participants were asked to select as many techniques as necessary based on their knowledge levels. Of the fifteen different rehabilitation techniques, seven were manual therapy based and required a trained professional, and the remaining eight were variations of exercises modalities.

Functional Range of Motion Self-Assessment.

The final section included functional testing that participants performed through a series of range of motion (ROM) tests to measure the mobility and function of their shoulders and neck (Figure 1). ROM tests included cervical range of motion measurements and shoulder flexion, shoulder internal and external rotation. Cervical range of motion measurements were taken for; lateral flexion where they aimed to touch their ear to the three fingers of the hand (Figure 1A & 1B), lateral rotation with a passing grade scored if the participants nose was over their shoulder (Figure 1C & 1D), and cervical flexion which passing grades were scored for successfully touching their chin to their chest (Figure 1E). Shoulder flexion was assessed with the participant sitting on the ground against a wall (to remove compensation) and raising arms overhead – an attempt was deemed successful if the participants straight arms touched the wall (Figure 1F). For shoulder internal and external rotation, the Apley's Scratch test was used and passing grades were given if fingers of opposite hands were able to touch (Figure 1G & 1H). All measurements were performed bilaterally and scores of pass or fail based upon the qualification criteria provided were self-reported by the participant.

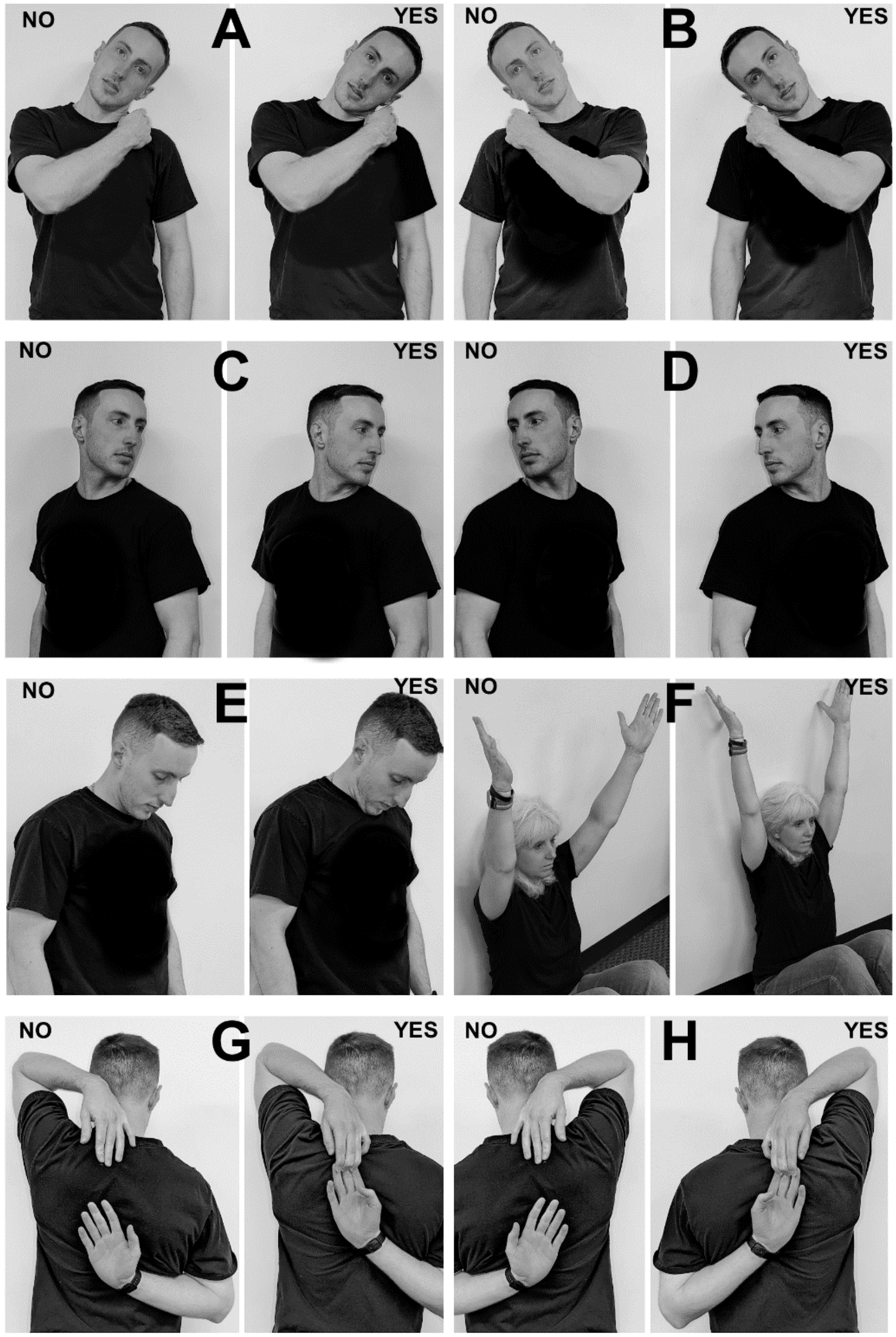

Figure 1. Cervical spine and shoulder range of motion tests. A) Lateral Cervical Flexion (left), B) Lateral Cervical Flexion (right), C) Cervical Rotation (left), D) Cervical Rotation (right), E) Cervical Flexion, F) Seated Shoulder Flexion, G & H) Apley's Scratch Test. 'No' indicates failure of test, 'Yes' indicates passing of test.

Statistical Analysis.

QuestionPro data analytics and Excel statistical packages were used to report and analyze quantitative data. Descriptive statistics and Pearson correlation coefficient (r) were used to report and compare data across the survey subsections.

Results

Demographics

Our survey captured 174 responses from college-aged students; however, 161 participants met the inclusion criteria for the study. The majority of participants were located at Texas-based university; however, the survey was disseminated to other institutions. Female participants comprised 64% of the total (Table 1). On average, participants ranked their activity level as a 6.8, which indicated that participants typically run about 6 to 10 miles per week, walk about 7 to 13 miles per week or spend about 1 to 3 hours per week in comparable physical activity. All BMI ranges fell within the healthy limit as defined by scoring less than 25.0. Of the 161 participants, 157 were from the United States, two from Australia, one from Sweden, and one from Spain.

Table 4. Demographic Data

	Male (n=58)	**Female (n=103)**	**Total (n=161)**
Age (years)	21.8 ± 1.8	21.5 ± 2.0	21.6 ± 2.0
Height (cm)	180.5 ± 9.7	165.2 ± 7.7	170.7 ± 11.3
Mass (kgs)	81.7 ± 11.5	65.8 ± 11.5	71.5 ± 13.8
Tegner Activity Scale	7.3 ± 2.6	6.6 ± 2.8	6.8 ± 2.7
Body Mass Index (BMI)	24.9 ± 3.5	24.1 ± 4.2	24.6 ± 4.8

Self-Reported Assessment of Posture

Responses from self-reported posture ratings and feelings towards posture are presented in Table 2. Participants largely agreed that their posture could be better and tended to rate their sitting posture as worse than their standing posture. Pain or discomfort in neck was also common during sleeping on back. Males also tended to feel more positively about their posture. Of particular importance, only 6.2% and 3.7%, respectively, rated their posture as ‘Very Good’, specifically outlining that there was no room for improvement. Standing posture was more commonly categorized as ‘Good but could be better’ (60.2%), while over 75% of participants rated their sitting posture as ‘Very Poor’ or ‘Poor and Needs Improvement’. Eighty-eight percent of participants wished their posture was better, and sitting posture was more commonly rated as ‘Poor and Needs Improvement’ than standing posture (53.4% & 31.1% respectively). Regarding pain during sedentary tasks such as sleeping or sitting, 64% and 49.1% reported pain when completing these two tasks (Table 2). It should be noted that this population was required to be free from any diagnosed acute or chronic musculoskeletal condition to be eligible for this survey study.

Table 5. Self-Reported Posture Ratings and Feelings Towards Posture

Total (n=161)	Very Poor		Poor and Needs Improvement		Good But Could Be Better		Very Good	
	Male	Female	Male	Female	Male	Female	Male	Female
How would you rate your standing posture?	1.7% (n=1)	2.9% (n=3)	17.2% (n=10)	38.8% (n=40)	67.2% (n=39)	56.3% (n=58)	13.8% (n=8)	1.9% (n=2)
Total	2.5% (n=4)		31.1% (n=50)		60.2% (n=97)		6.2% (n=10)	
How would you rate your sitting posture?	13.8% (n=8)	26.2% (n=27)	50% (n=29)	55.34% (n=57)	29.3% (n=17)	16.5% (n=17)	6.9% (n=4)	1.9% (n=2)
Total	21.7% (n=35)		53.4% (n=86)		21.1% (n=34)		3.7% (n=6)	

	No			Yes		
	Male	Female	Total	Male	Female	Total
Do you wish your posture was better?	20.7% (n=12)	5.8% (n=6)	11.2% (n= 18)	79.3% (n=46)	94.2% (n=97)	88.8% (n=143)
Pain or discomfort in back/upper body when sleeping on back	75.9% (n=44)	57.3% (n=59)	36.0% (n=58)	24.1% (n=14)	42.7% (n=44)	64% (n=103)
Pain in back or shoulders when sitting	77.6% (n=45)	31.1% (n=32)	50.9% (n=82)	22.4% (n=13)	68.9% (n=70)	49.1% (n=79)
Is your office/desk ergonomically set-up?	51.7% (n=30)	68.9% (n=71)	62.7% (n=101)	48.3% (n=28)	31.1% (n=32)	37.3% (n=60)

Neck Disability, Dispositional Positive Emotion Scale, and Correlation Findings

Of the 161 participants, 65.2% reported having ‘No Disability’ per the NDI scoring system – meaning they had cumulative scores of 0 to 4 for the 10 questions. Despite the inclusion criteria specifying no acute or chronic musculoskeletal injury to the neck or upper body, 32.3% and 2.5% of participants scored ‘Mild Disability’ and ‘Moderate Disability’ respectively. Of the ‘Mild Disability’ scores, 42 females (40.7%) scored in this category. For the DPES scoring, the average male score was a 5.6 ± 1.0 and the average female score 5.3 ± 1.0. The lowest score for individual question scores in both groups was the question asking 'People Usually Recognize My Authority' with scores of 5.2 ± 1.6 and 4.9 ± 1.6 for males and females respectively.

There was a moderate-strong correlations between poor sitting and standing posture (r=0.61) and moderate correlations were seen between the desire to improve posture and a participants self-rating of their standing (r=0.43) and sitting (r=0.46) postures (Table 3). However, there were weak correlations (r<0.30) between self-rating of posture and NDI and DPES scores, which indicated there was not a reportable relationship between posture beliefs, neck disability, and psychological wellbeing scores (Table 3).

Table 6. Correlational data between self-reported posture beliefs and patient-rated outcome scales.

	Do you wish your posture was better?	**How would you rate your STANDING posture?**	**How would you rate your SITTING posture?**	**NDI Total**	**DPES Total**
Do you wish your posture was better?	1				
How would you rate your STANDING posture?	0.43	1			
How would you rate your SITTING posture?	0.46	0.61	1		
NDI Total	-0.24	-0.23	-0.28	1	
DPES Total	0.19	0.20	0.19	-0.14	1

Functional Range of Motion Self-Assessment

The eight self-assessments of functional range of motion produced mostly passing values across both neck and shoulder range of motions. The percentage of participants that recorded a pass for the neck range of motion assessments are as follows: Cervical Forward Flexion (94.8%), Cervical Lateral Flexion (Right) (85.6%), Cervical Lateral Flexion (Left) (83.9%), Cervical Rotation (Right) (93.7%), and Cervical Rotation (Left). The percentage of participants that recorded a pass for the shoulder range of motion assessments are as follows: Seated Shoulder Flexion (87.9%), Apley's Scratch Test (RA over) (70.7%), Apley's Scratch Test (LA over) (56.3%). We expected that there would be differences regarding the Apley's Scratch tests as usually the non-dominant arm has less range of motion than the dominant arm. Although, we did not ask our participants which arm was their dominant arm, we can conclude that likely most of our participants were right-handed.

Knowledge of Rehabilitation Techniques

Figure 2 contains data demonstrating that cupping and acupuncture techniques yielded the largest recognition rate amongst the manual therapy techniques (60.2% and 40.3% respectively), while stretching and resistance training topped the exercise modality list (90.1% and 82.6%). Feldenkrais, Alexander, and Rolfing techniques were the least known rehabilitation techniques with 3.1% of participants being familiar with each of those. Only 2.4% of participants did not recognize any of the fifteen techniques listed (Figure 2).

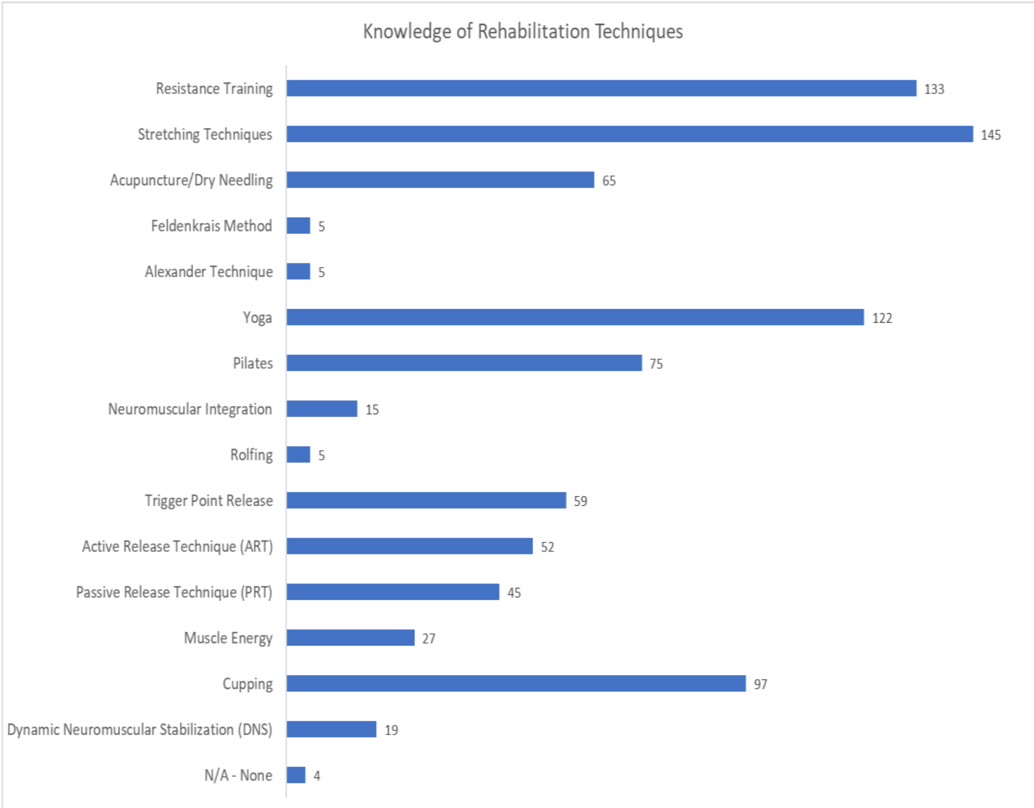

Figure 2. Knowledge of rehabilitation techniques

Discussion

Self-reported posture yielded only 6.2% and 3.7% of participants reporting their posture as not needing improvement while standing and sitting, respectively. While 36% and 40.9% reported pain between their shoulders when attempting to sleep on their back and while sitting, respectively. These two findings highlight two key aspects of concern: 1) that college-aged students recognize their posture needs improvement, and 2) that it is impacting their ability to be comfortable in two basic rest positions.

When comparing these self-reported measures to validated outcomes such as the NDI, 34.7% (n=56) of participants reported having some level of disability based on the NDI's scoring parameters. Of these, 92.9% were classified as 'Mild

Disability', and 7.1% as 'Moderate Disability' per the NDI classification index. It should be reiterated that all participants were free from acute injury and had no history of surgery to the upper extremities or torso. The average NDI score was 4.6 ± 4.3 which is slightly lower to those seen by Ahmed et al. [50] (5.9 ± 2.3) and Gong et al. [51] (7.0 ± 5.8) who also investigated college-aged populations.

The DPES consists of seven subscales that aim to measure the propensity for an individual to feel positively towards others in their daily lives amongst the various subscales. The Pride subscale specifically was chosen because the questions asked aligned closely with nonverbal communication findings by Mehrabian [49], Burgoon and Dunbar [17], and the work by Coulson [47]. Such works in the nonverbal communication literature closely align with postural dysfunctions such as FHP and RSP. Shiota et al. [52] demonstrated that the DPES-Pride subscale had a moderate correlation with Extraversion, and a moderate negative correlation with Neuroticism – two of the five traits in the Big Five Inventory (BFI) of personality traits.[53] We reported a positive correlation between participants thoughts about their sitting and standing posture, and their scores in the DPES-Pride subscale. Our participants demonstrated greater positive feelings when they indicated that their posture was better.

Arguably the biggest strength of this study was the high number of college-aged participants that self-reported patterns of poor posture. Sitting posture had 35 participants (21.7%) rank as 'Very Poor' compared to standing posture which had 4 (2.5%) which was noteworthy considering the 62.7% of individuals who do not believe their workplace to be ergonomically set up. With the onset of COVID-19 pandemic, education systems employed online and hybrid delivery methods for college-aged populations, thereby reinforcing a sedentary lifestyle which is a risk factor for bad posture. Although our participants did not exhibit deviations in functional range of motion in their neck and shoulders, their knowledge of rehabilitation techniques to fix these bad postures was clearly biased to more traditional methods such as resistance training, stretching, yoga, and cupping, with little to no knowledge about posture-specific rehabilitation techniques such as Feldenkrais and Alexander techniques.

Additionally, the breadth of the survey questions allowed for multiple facets to be assessed related to posture. Nonverbal communication literature has long supported the relationship between posture and psychological disposition through the notable works of Dr. Albert Mehrabian and Dr. Judee Burgoon in particular.[16,17,49] As such, it is easy to see this study being a precursor to many future studies to take a more detailed look on the various aspects investigated, particularly with a larger emphasis on the relationship of posture to psychological outcome measures. We only used one psychological subscale in this study, but we encourage that other domains that encompass physical, mental and social aspects of health be employed in future studies.

One limitation of study is how geographically bound the participants were. Ninety-seven and a half percent of participants where from the United States, and 77% of those were from Texas. Future studies would be wise to increase the breadth of participants involved to get a better understanding of posture beliefs and impacts across a broader population.

Conclusion

This study reinforces the notion that posture issues are prevalent in today's society amongst both college-aged and adult populations.[23-25] Results from this study clearly show that participants were able to identify their poor posture and recognize their need to improve it in both sitting and standing settings, but they may not be familiar with rehabilitation techniques that are designed to fix or maintain posture.

Identifying that we have an issue with posture and the prevalence of pain in healthy, college-aged populations demonstrate the need for intervention in this population group. Not only would this aim to improve an individual's health, but also reduce the potential for future impact on a society level through health care costs and loss of work productivity.

Future research should aim to focus on measuring posture in college-aged populations to investigate if individuals who identify as having "bad posture" indeed have less desirable posture as determined by measures such as craniovertebral angle and scapular index. If such relationships exist, interventions can focus on musculoskeletal intervention, and education of good postural habits.

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CHAPTER 3

A NEUROMUSCULAR INTEGRATION APPROACH TO THE REHABILITATION OF FORWARD HEAD AND ROUNDED SHOULDER POSTURE: SYSTEMATIC REVIEW OF LITERATURE

Abstract
Objective: The aim of this study was to review the scientific literature on the efficacy of neuromuscular integration techniques for the rehabilitation of forward head posture (FHP) and rounded shoulder posture (RSP). Data Sources: Online databases CINAHL, PubMed, and SportDiscus were searched for the Boolean terms: "*neuromusc* AND shoulder AND posture*", "*neuromusc* AND neck AND posture*", "*neuromusc* AND head AND posture*". Study Selection: Reviewed studies were limited to human studies with an exercise intervention, and exclusion of studies that contained participants with severe chronic conditions or acute musculoskeletal injuries. Data Extraction: One reviewer extracted data on study and patient characteristics and selected articles were evaluated by 2 raters for methodological quality. Data Synthesis: A total of 281 subjects participated in the six chosen studies that met the inclusion criteria. Exercise intervention protocols were then reviewed and recommendations were made accordingly for the FHP and RSP respectively. Conclusions: Evidence showed efficacy of neuromuscular techniques on FHP, but not for RSP. This review also highlighted the lack of research in this field, and the ambiguity in practice for what constitutes a neuromuscular integration method.

Keywords: Exercise intervention, craniovertebral angle, dysfunction

Abbreviations: FHP = forward head posture, RSP = rounded shoulder posture, ACL = anterior cruciate ligament, UCL = ulnar collateral ligament, PNF = proprioceptive neuromuscular facilitation, CVA = craniovertebral angle, C7 =

seventh cervical vertebrae, DNS = dynamic neuromuscular stabilization, IC = ischemic compression, PEF = peak expiratory flow, CMCPS = chronic myofascial cervical pain syndrome

Introduction

Forward head posture (FHP) and rounded shoulder posture (RSP) are common postural misalignments caused by muscular imbalance that lead to a variety of pain patterns in the neck and shoulder.[1,2] FHP prevalence ranges from 61% to 85% and is associated with RSP.[3-7] RSP prevalence ranges from 66% to 78%.[3,5,7] Importantly, FHP and RSP have a number of negative effects on health and functioning, highlighting that these postural misalignments are of major societal concern.[2]

FHP is characterized by weakening of the deep neck flexor muscles causing increased cervical lordosis[8] and a protruding head position due to the shortening of the semispinalis cervicis and capitis, along with the upper trapezius and levator scapulae. RSP is typically seen with scapula anterior tilt and internal rotation of the scapula giving a forward and rounded protrusion of the shoulders, caused by shortened pectoralis minor and weakness in the middle trapezius, lower trapezius, and serratus anterior.[9-11]

Researchers have linked FHP and RSP to a range of negative functional signs and symptoms, such as increased pain and muscle strain,[12-16] decreased strength and range of motion of the mandible, neck, and shoulders,[17-21] a reduction in respiratory function,[22-26] a decrease in stability,[27,28] and alterations in muscle activation patterns and scapular kinematics and position.[1,29-32] FHP and RSP have also been linked to etiological pathologies such as temporomandibular joint dysfunction syndrome,[33-35] thoracic outlet syndrome,[33,36,37] chronic neck pain,[7,15,38] shoulder overuse injuries,[1] scapular dyskinesis,[31] and even cardiorespiratory impairments.[39] The breadth of these negative effects demonstrates that FHP and RSP are major upper body pathologies in need of addressing.

According Griegel-Morris et al. [3], 66% of the 20-50-year old healthy subjects studied demonstrated FHP, and prevalence of RSP was reported to be 73% and 66% for right and left shoulders respectively. Thus, given the prevalence of FHP and RSP and their negative consequences for health and optimal functioning, an important question is how to remediate these conditions. Traditionally, clinicians have remediated these postural misalignments through isolated exercise rehabilitation protocols – that is, stretching the overactive muscles and strengthening the underactive muscles. This literature review examines the prevalence and effectiveness of a training methodology known as neuromuscular integration for the rehabilitation of FHP and RSP. In neuromuscular integration approaches, clinicians undertake rehabilitation in a more holistic manner, focusing on optimizing the patient's ability to stabilize joints and postures, react to proprioceptive changes, and improve activation patterns.

This approach of incorporating neuromuscular training into rehabilitation has become increasingly popular, particularly for lower extremity injuries impacting the ankle, knee, and hip. The literature on anterior cruciate ligament (ACL) rehabilitation literature, in particular, is littered with articles related to 'neuromuscular control,' which is defined as muscle strength, power, and activation patterns [40] which can be extended to control of the core and trunk in the coronal plane.[41]

Research on the lower extremity has revealed altered muscular recruitment patterns following injury.[42,43] Intriguingly, injuries to the upper body appear to influence lower body functioning, highlighting the integrated nature of human movement. For example, Garrison et al. [44] compared the lower extremity balance ability of baseball players with ulnar collateral ligament (UCL) tears to a healthy cohort and found poorer balance in those who had sustained an injury. Further supporting the integrated nature of human functioning, Moustafa and Diab [13] augmented their management of lumbosacral radiculopathy with FHP corrective exercises and observed reductions in pain and improvements in function for these patients.

Neuromuscular training can improve proprioception and stability[45] and induce isokinetic strength gains.[46] Research has also identified neuromuscular control as a potential prophylactic measure and indicator of injury risk.[47,48] The positive results of a neuromuscular integration philosophy applied to lower extremity injuries, combined with evidence of the integration between upper and lower body in functional movement, suggests there is value in exploring the effects of neuromuscular training on FHP and RSP.

Given the aforementioned background, the aims of the current study were: (i) to assess the availability of research for treating FHP and RSP using a neuromuscular integration exercise approach, and (ii) to critically review the scientific evidence for the effectiveness of these approaches on rectifying these maladaptive postures.

To identify the prevalence of neuromuscular integration approaches to FSP and RSP, we performed a systematic literature search to examine what evidence exists to support the use of neuromuscular training to treat these postural deviations. We considered exercise interventions neuromuscular in nature if they incorporated more than just isolated strengthening and stretching and instead used techniques such as proprioceptive neuromuscular facilitation (PNF) exercises, proprioception or stability training, or exercises that targeted core stability.

Methods

Data sources

A computerized search was conducted of all English available peer-reviewed scientific papers in CINAHL, PubMed, and SportDiscus. Studies were collected up to December 2020, with all articles being published between 2010-2020. To maximize the available literature on posture, searches included the terms head, neck, and shoulder. The following Boolean terms were used: “neuromusc* AND shoulder AND posture”, “neuromusc* AND neck AND posture”, “neuromusc* AND head AND posture”.

These terms were used to encompass all truncated forms of the potential term “neuromuscular”, and the specific body part search was varied on each search engine due to the ambiguous definition of these postures.

Study Selection and methodological quality

Fig. 1 shows the PRISMA Flow Diagram of the processes used to select the final papers for review. A total of 392 papers were identified in the initial search. After removing duplicates and those not related to posture 184 remained. These remaining studies were checked to ensure they used human subjects, included no chronic conditions such as Cerebral Palsy or Parkinson's Disease, no acute musculoskeletal injury, and contained an exercise intervention. The reference sections of the remaining articles were searched for any appropriate studies that fit the description, leading to the identification of three additional articles – leaving the final study count with six articles.

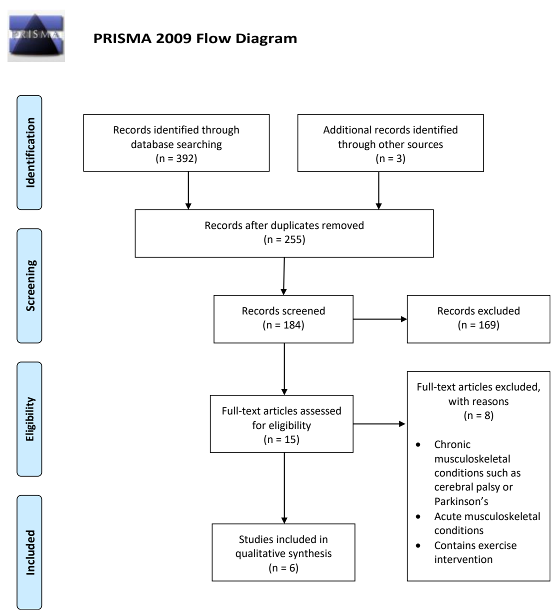

Figure 1 PRISMA flowchart paper selection

Of the final six studies, five were randomized control trials. These were assessed using the Cochrane risk of bias assessment (Table 1), with all showing a low level of bias on all measures of bias assessment. The analyses of these five articles demonstrated heterogeneity in methodology.

The remaining article from Szczygieł et al. [49] was not a randomized control trial, thus it was excluded from the bias assessment tool.

Table 1. Cochrane's Risk of Bias Assessment Tool

Risk of bias criteria	Birinci et al. (2020)	Lee et al. (2017)	Kim et al. (2019)	Moustafa et al. (2018)	Won-Sik et al. (2019)
Domain 1: Risk of bias arising from the randomization process	Low	Low	Low	Low	Low
Domain 2: Risk of bias due to deviations from the intended interventions	Low	Low	Low	Low	Low
Domain 3: Risk of bias due to missing outcome data	Low	Low	Low	Low	Low
Domain 4: Risk of bias in measurement of the outcome	Low	Low	Low	Low	Low
Domain 5: Risk of bias in selection of the reported result	Low	Low	Low	Low	Low

Data Extraction

The results of the literature search are reported according to the specific technique of neuromuscular integration used, followed by the specific results these interventions had on FHP and RSP. The intervention strategies are described in detail and include the aim of the intervention, targeted musculature, and measurement techniques used. Table 2 provides background information for each study as well as a summary of the protocol and the results.

Table 2. Article Review Summary

	Birinci (1)	Lee (2)	Kim (3)	Moustafa (4)	Szczgiel (5)	Won-Sik (6)
Year of Publication	(2020)	(2017)	(2019)	(2018)	(2018)	(2019)
Country of Origin	Turkey	South Korea	South Korea	UAE	Poland	South Korea
Aim of Paper	Investigate which type of stretching exercise used after ischemic compression (IC) was more effective on latent trigger points in pectoralis minor	Determine the effect of forward head posture (FHP)-improving exercises on rounded shoulder posture (RSP) when employing the self-stretch exercise, McKenzie exercise, and the Kendall exercise as intervention methods.	Investigate the effects of the McKenzie exercise program on forward head posture and respiratory function.	Investigate the functional and pain response outcomes of denneroll cervical extension traction compared to standard care in patient cases with chronic myofascial cervical pain syndrome (CMCPS)	Evaluate the effect of whole program exercise for activating deep stabilizer muscles on the posture and quality of respiratory movements.	Investigate the effects of dynamic neuromuscular stabilization (DNS) exercises on the vertebral structures and forward head postures of participants with forward head posture.
Target Population	40 participants (6 male), aged 18-35 years old	28 participants, aged 19 years and older	30 adult men and women aged 20-29	120 patients (76 male) with chronic CMCPS, average age of 33.1 and 31.9 in the two groups	18 participants, aged 20-30 years old	45 participants in their 20s
Protocol	Single-event stretching intervention Divided into 4 groups: 1) IC with contract-relax PNF stretching 2) IC with static stretching 3) IC with myofascial release 4) no intervention. Tests immediately after and 24hr post	8-week training intervention, 25mins/day, 3x week, for 8 weeks Divided into 3 Groups: 1) McKenzie Exercise Group 2) Self-Stretch Exercise Group 3) Kendall Exercise Group	15 experimental 15 control Experimental exercises incorporated seven McKenzie exercises 20mins/day, 3x week, for 4 weeks.	Intervention and control groups both received integrated neuromuscular inhibition techniques (INIT), intervention group received denneroll cervical traction device. 10 weeks treatment time, immediate assessment post intervention and 1 year follow up	3 times per week for 4 weeks. Breathing exercises performed while prone, bridging, on all 4's, and on unstable surface	6-week training intervention. Group A performed neck stabilization exercise. Group B performed stretching and extensor strengthening exercise.
Results	Treatment methods using proprioceptive neuromuscular facilitation (PNF) techniques produced statistically significant improvements in RSP as measured by Pec Minor Index and Pec Minor Length.	Significant differences in craniovertebral angle (CVA) and scapular index in all groups, no significant differences between the groups.	CVA significantly improved in the experimental group. No significant difference was found in the control group. Respiratory measures were significantly improved in experimental group. Not so in the control.	Patients suffering from cervical myofascial pain syndrome completed integrated neuromuscular inhibition technique and saw improvements in neck disability, pain intensity, and posture (CVA, Shoulder angle).	Deep stabilizer muscle exercises resulted in a significant change in the position of the body in the sagittal plane (posture) as well as an increase in the amplitude of breathing (optoelectric body explorer).	All exercise modalities improved FHP even in the DNS group who also saw improvements in core muscle activity and endurance indicating that DNS improves posture and ancillary measures. Measured using whole-body posture measurement system (GPS 400).

Results

Content Description

Of the six eligible papers, one used variations of an acute, single-bout stretching session following ischemic compression (1), one implemented a denneroll traction device combined with neuromuscular inhibition techniques (4), and the remaining five articles focused on stabilization and strengthening of involved musculature using neuromuscular integration techniques (2-3, 5-6).

The heterogeneity in study designs, participant populations, forms of neuromuscular integration, durations of interventions, dependent measures, and quantification of FHP and RSP prevented an integrated presentation or meta-analysis of the findings. Therefore, the four FHP articles are summarized separately and the two RSP articles are summarized separately.

Forward Head Posture

In the selected papers, four articles reported on FHP (3-6) and used varying methods to do so, and all articles implemented their own unique form of neuromuscular integration for the rehabilitation of FHP. Kim et al. [50] used the McKenzie exercise program to investigate changes in FHP and respiratory function. Moustafa et al. [51] used integrated neuromuscular inhibition techniques in conjunction with a denneroll cervical traction device. Szczygieł et al. [52] performed breathing variations aimed at activating the deep core musculature, particularly the transverse abdominus, multifidus, and internal oblique muscles. Won-Sik et al. [53] examined three groups with different modalities of treatment including; Dynamic Neuromuscular Stabilization (DNS) techniques, McKenzie neck stabilization exercises, and cervical extensor stretching and strengthening.

Kim et al. [50] investigated the effects of the McKenzie exercise program on FHP and respiratory function in 30 adult men and women following a four-week training exercise protocol. Participants with FHP, as measured by craniovertebral angle (CVA), completed McKenzie exercises three times a week for four weeks, while control group participants received no intervention. CVA is a common FHP measurement technique that involves photographing a subject from the lateral view and marking cervical vertebrae seven (C7) and the tragus of the ear. A vertical line bisects the C7 mark and a diagonal line is drawn from the C7 marker to the tragus. The CVA is the angle between the vertical and diagonal line. A

CVA of less than 49° was required and used for measurement of FHP. Forced vital capacity (FVC), FVC% predicted, forced expiratory volume at one second (FEV_1), and FEV_1 % predicted were measured for respiratory function.

The McKenzie exercises included: head retraction with overpressure while seated, neck extension while seated, head retraction with overpressure while lying, neck extension while lying, side bending of the neck while sitting, neck rotation while sitting, and neck flexion with chin-in in the siting position. These exercises were performed for seven seconds at static maximum muscle strength with a three second rest between each motion, and this was repeated 15-20 times. Exercise sessions lasted approximately 20 minutes and were completed three days per week for four weeks.

Kim et al. found significant differences in CVA and all respiratory measures between pre- and post-tests for the exercise group, and no differences for the control group. Between groups, only CVA and FVC% predicted were statistically different after the four-week intervention. The authors acknowledged that the small sample size and lack of long-term follow-up were limitations of the study. In addition, it could be argued that a longer intervention duration may have resulted in more pronounced results.

Moustafa et al. [51] randomly distributed 120 patients with chronic myofascial cervical pain syndrome (CMCPS) into a control or intervention group to complete a 10-week exercise intervention. They investigated the functional and pain response outcomes of the denneroll cervical traction device compared to traditional care – this traditional care implemented various neuromuscular integration techniques. Both groups received the integrated neuromuscular inhibition techniques (INIT), ischemic compression, strain counterstrain (SCS), and muscle energy techniques as their treatment intervention, but only the intervention group received the denneroll cervical traction device, aimed at improving cervical lordosis and alleviating FHP. Both groups also completed daily home exercises. This prospective, investigator-blinded, randomized clinical trial included patients with a cervical lordosis of less than 25^{o} and a FHP measurement using craniovertebral angle (CVA) of less than 50^{o}. Exercises and traction were performed three times per week for 10 weeks, with measurements taken at baseline, 10 weeks and 1-year post intervention.

Both groups exhibited statistically significant changes in NDI, pain intensity, algometric pressure, posture parameters, and cervical ROM after 10 weeks, however, the changes were significantly greater in the intervention group compared to the traditional care group for algometric pressure, posture parameters, and cervical ROM. At the 1-year follow up, the intervention group demonstrated significantly better outcomes than the traditional care group for all of the dependent measures, highlighting the superiority of the denneroll traction device in inducing positive changes in posture, pain, and function.

The authors attempted to blind participants to the group they were in by using a placebo traction method involving a small cervical towel in place of the denneroll device for control subjects. This sham traction force for the control group was used in a similar manner to the intervention group, but without applying a significant enough extension force to sufficiently bend the spine to mimic the intervention. Though the use of a placebo traction method was a clear strength of the study, sampling of the participants from a single clinic for convenience limited the ability to extrapolate these results out to a larger population.

Szczygieł et al. [52] recruited 18 volunteers aged 20-30 from a healthy, nonsmoking population without respiratory issues to complete a 4-week training intervention aimed at activating the deep stabilizers. The researchers evaluated how deep stabilizer muscle training would impact postural control and quality of breathing movements. Posture was measured using the optoelectric body explorer (OBE), which uses reflective markers placed on various anatomical landmarks to measure posture of the head, pelvis, and trunk in two dimensions. Reflective markers on the central part of the upper lip, occipital tuberosity, and the reference y-axis were used to measure FHP. Participants completed exercises three times per week for 4-weeks, which were designed to activate the transverse abdominus, multifidus, and internal obliques.

Exercises were performed supine, bridging, in a four-point kneeling position, and on unstable surfaces consisting of three sets of holding specific postures for 10 seconds, resting for five seconds, and repeating for 10 repetitions. Results showed improvements in sagittal plane trunk posture and abdominal excursion, but no other statistically significant improvements in sagittal plane head posture (FHP) were found after the 4-week training intervention.

Limitations of this study included the relatively small sample size, lack of control group, and lack of integration of other deep stabilizing musculature in the exercise intervention. Szczygieł et al. [52] noted that any future programs should include exercises aimed at improving head and upper body control, such as incorporating serratus anterior activation or FHP exercises. In addition, the biomechanical aspect of breathing was not measured through pulmonary function. Future studies would be wise to include this measure.

Won-Sik et al. [53] measured the effects of dynamic neuromuscular stabilization (DNS) exercises on changes in FHP in 45 participants in their 20s divided into three equal groups. The intervention lasted for six weeks. To measure FHP, researchers used the GPS 400 system and drew perpendicular induction lines through the center of the humerus and the outer ear line to calculate degree of FHP. Participants with 1cm or greater distance between these two points were deemed eligible for the study. Thoracic kyphosis and lumbar lordosis were also measured using the GPS 400 system. In addition to the dynamic neuromuscular stabilization (DNS) group, the authors included two control groups. Control group A performed neck stabilization exercises and control group B performed stretching and extensor strengthening exercises.

The intervention group's exercises involved using a pressure biofeedback device placed at the waist until the pressure measured 60 mmHg. Participants were then asked to increase this pressure by a further 10 mmHg by inhalation and exhalation. This pressure biofeedback device was then placed under the neck of the participant and used while performing neck stabilization exercises in static positions for 10 seconds and repeated 10 times at a pressure of 20 mmHg. The pressure was increased by two mmHg and repeated until the participant achieved a final measurement of 30 mmHg. Control group A completed the McKenzie neck strengthening exercises [same as those completed by Kim et al. (2019) with the omission of two exercises], and control group B used isolated neck strengthening exercises with the same repetition and set structure as above.

Measurements performed at baseline, 3-weeks, and 6-weeks revealed that all three intervention groups improved FHP, thoracic kyphosis, and lumbar lordosis significantly after 6-weeks. No interaction effect was found between the three groups, indicating that although the DNS intervention was effective, it was no more effective than the exercises performed by either control group – one of which specifically implemented McKenzie neck stabilization exercises. Although no significant difference was found between the groups, Won-Sik et al. [53] demonstrated that implementing a DNS exercise program yielded postural results independent of specific isolation of the affected areas, highlighting the efficacy of a neuromuscular approach to rehabilitating postural dysfunctions.

Rounded Shoulder Posture

Two articles measured RSP (1-2). Birinci et al. [54] measured RSP and respiratory function following an intervention utilizing different types of stretching maneuvers and manual therapy. Lee et al. (2017) utilized FHP interventions (similar to those listed above) to investigate the impact those exercises had on RSP. Unfortunately, with RSP there is no consensus on a gold standard for measurement like the CVA measure for FHP. As such, these two studies used different measurement techniques.

Birinci et al. [54] measured RSP using Pec Minor Length, Pec Minor Index, and lying acromion to table distance – all of which have been validated previously. The aim of this study was to investigate the best neuromuscular stretching technique following a single session ischemic compression (IC) manual treatment. Consequently, there was no specific strengthening protocol put in place for this study, but the PNF stretching techniques utilizes muscle contractions at end-stage ROM and was deemed a neuromuscular technique.

The 40 study participants were randomly divided into four equal study groups: group 1 used IC with a modified contract-relax PNF stretch, group 2 used IC with a static stretch, group 3 used IC with myofascial release, and group 4 had no intervention. A physiotherapist performed all IC's, a second, blinded therapist performed the stretching interventions, and a third physiotherapist performed all other assessments and data collection. Postural and respiratory outcome measurements were collected at baseline, immediately after the intervention, and 24 hours following the intervention.

This acute study showed differences in Pec Minor index in the PNF group and myofascial release group immediately and 24 hours after the intervention. The PNF group was the only group to report a statistically significantly improvement in pain pressure threshold immediately after the intervention. Pec Minor length improved in the PNF and myofascial release groups and FEV1, peak expiratory flow (PEF), FEV1/FVC, and maximum expiratory pressure all improved in the PNF group. The myofascial release group was the only other group to see improvements in respiratory function, with significant differences in maximum inspiratory pressure and maximum expiratory pressure. Non-significant changes were seen in the other groups and no group saw improvements in RSP.

Although Birinci et al. [54] did not utilize an extended exercise protocol, they still found improvements in pectoralis minor length and respiratory measures. This finding suggests that a longer PNF intervention may lead to improvements in RSP.

Do Youn Lee (2017) split 28 participants into three distinct exercise groups: McKenzie exercise group (9), Kendall exercise group (9), and self-stretch exercise group (10) to determine whether neuromuscular exercises designed to improve FHP could also improve RSP. The exercise interventions lasted 25 minutes per day and were done three times per week for eight weeks. Measurements were taken pre- and post-intervention. Although the intervention focused on RSP and used the scapular index, FHP was also measured using the traditional CVA.

The McKenzie exercises were identical to those listed in the Kim et al. (2019) paper. The Kendall exercises were more traditional, focusing on 15 repetitions of isolated stretching and strengthening techniques more commonly seen in FHP treatments. The self-stretch group performed 10 sets of 10 second stretch holds followed by five seconds of rest on the various neck musculature.

At the end of the training intervention, all groups showed statistically significant improvements from pre- to post-measures, but there was no statistically significant difference between groups for either FHP or RSP.

Although no differences were found between groups, much like in Won Sik et al. (2019), the findings demonstrated that a neuromuscular integration approach to FHP and RSP can still yield results. In particular, the exercises prescribed by Do Youn Lee et al. focused on correcting FHP to investigate the impact these exercises had on RSP – demonstrating the efficacy of a non-specific neuromuscular approach for treating postural dysfunction.

Discussion

This literature review aimed to identify and critically evaluate evidence for the efficacy of implementing a neuromuscular integration approach to the treatment of FHP and RSP in adult individuals. As discussed earlier, because neuromuscular integration techniques are commonly implemented in lower body rehabilitation programs, there is a need to investigate the efficacy of this training method for upper body rehabilitation. It is difficult to draw firm conclusions from the review, but a range of neuromuscular integration techniques appear to have the potential to correct FHP and RSP. Overall, however, the current evidence for the effectiveness of neuromuscular integration techniques in upper body rehabilitation is moderate given the limited number of studies, their heterogeneity, and the positive changes seen in control groups that were exposed to non-neuromuscular integration techniques, thus supporting the idea that more research is clearly needed.

Over a period of 10 years (2010-2020), six studies with strong methodological quality and low risk of bias were conducted. These studies included five RCTs and an observational study that evaluated the level of posture restoration using neuromuscular integration techniques in a combined total of 281 adult individuals. All five RCTs reported improvements in FHP and RSP, while the observational study did not reveal any changes in FHP and did not include a control group for comparison purposes. Despite the consistent improvements reported in the five RCTs, it is important to note that these improvements were generally equal to those of participants in control groups who received non-neuromuscular integration techniques. At the very least, these findings suggest that neuromuscular integration techniques are as effective as well-established exercise protocols, like McKenzie and Kendall, for improving upper body posture.

Two interrelated factors cloud the interpretation of the findings from this review and the conclusions that can be reached. The first is the lack of agreement in the field of rehabilitation on what constitutes a neuromuscular integration technique. The second factor, which logically stems from the first, is the high degree of methodological heterogeneity in the studies included in the review.

With regard to the first factor, the lack of agreement in exercise based physical rehabilitation as to what constitutes neuromuscular integration is clearly problematic. Myer et al. [55] referred to neuromuscular training as a training model to enhance health and skill-related components of physical fitness – this includes training modalities such as strength and conditioning modalities that focus on resistance and core-based strength, as well as stability, plyometric and agility training. Typically, in the lower extremity literature we see references to controlling the frontal and transverse planes of movement[56] and ability to control the body's trunk during exercise.[57] Despite only one article measuring trunk posture (5), all articles integrated neuromuscular principles in their exercise selection which focused on exercises involving multiple planes of motion. Well established methodologies such as the McKenzie, Kendall, and DNS protocols were used in half of the studies, all of which led to improvements in the posture measurements (2, 3, 6), although sometimes these protocols were assigned to participants in the control groups rather than the primary intervention group. The remaining studies (1, 4, 5) implemented less structured methodologies, such as manual therapy techniques and home exercise prescription, and saw more mixed results.

With respect to the second factor, methodological heterogeneity was particularly high in terms of how the interventions were supervised and their durations. Three studies relied solely on home-based intervention protocols (2, 3, 5), one was a mix of home-based and therapist supervision (4), and the remaining two were treatment protocols led by a therapist (1, 4). Regarding duration, the studies ranged from an immediate intervention protocol to 10-week exercise interventions. For the purpose of comparison, exercise intervention protocols for treating FHP and RSP using non-neuromuscular approaches typically range from 6-12 weeks in duration.[13,58-64] Specifically, the neuromuscular intervention-based exercise programs included in this literature review had the following durations: immediate (1), 4-weeks (3, 5), 6-weeks (6), 8-weeks (2), and 10-weeks (4) – meaning half of the articles in the current review used durations that fell below the typical duration of non-neuromuscular intervention protocols. It is also informative to compare the durations of the protocols used by the studies in the current review with the durations of neuromuscular integration protocols for the lower extremity. Traditional neuromuscular integration approaches for the lower extremity typically range from 6-10 weeks in duration or can be season-long interventions in certain sporting contexts.[56,65-72] Therefore, it could be argued that lack of improvement in posture in the two RSP articles[54,73] could be attributed to the fact that neither study reached the 6-week threshold considered ‘typical’ for a neuromuscular training intervention.

Finally, research on FHP has long used CVA as a valid and reliable measure of FHP,[74,75] but RSP has no equivalent gold standard of measurement. The two articles that measured RSP used different measurement techniques. Birinci et al. [54] measured RSP by having the participant lie supine on a table, legs bent, with arms by their side, and measured the vertical distance between the posterior border of the acromion and the table. This technique’s obvious flaw is the lack of functionality - with the patient in a non-weightbearing, non-standing position to measure posture. In contrast to Birinci et al., Do Youn Lee et al. [73] used the scapular index method which is becoming increasingly popular. It is performed with the patient standing in a relaxed posture. A tape measure is used to measure the distance between the sternal notch and coracoid process and the distance between the posterolateral angle of the scapula (acromion) to the thoracic spine is recorded. The former becomes the numerator and the latter the denominator, with the resultant number multiplied by 100 to capture a final measurement.[76] Lack of a gold standard of measurement for RSP compromises the repeatability and generalizability of findings generated by studies designed to test the efficacy of interventions for this type of postural deviation.

In conclusion, more research is needed before firm conclusions can be drawn about whether the implementation of neuromuscular integration techniques is an effective method for treating upper body postural disorders. The findings from this literature review indicate that this rehabilitation approach is effective for FHP, but the effectiveness of the approach for RSP is less clear. In the reviewed articles, the neuromuscular integration techniques were never shown to be inferior to traditional approaches to correcting these postural deviations, indicating that as this field continues to grow in evidence and practice, patients exposed to these techniques are unlikely to experience detrimental effects. The review also highlighted alternative avenues for application of these techniques, such as in the improvement of respiratory function.

Overall, it appears that neuromuscular integration techniques have the potential to correct FHP and RSP in otherwise healthy individuals, although further research is clearly required before definitive alterations in current exercise prescription methods for the treatment of FHP and RSP can be recommended.

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CHAPTER 4

INVESTIGATION INTO THE PHYSICAL AND PSYCHOLOGICAL DIFFERENCES IN COLLEGE-AGED STUDENTS WITH AND WITHOUT FORWARD HEAD POSTURE

Abstract

Background: Forward head posture (FHP) impacts a large subset of the population and has been linked to a variety of musculoskeletal pathologies, but investigations into the psychological ramifications are less prevalent despite the strong supporting nonverbal communication literature. **Objective**: To investigate the physical and psychological differences between college-aged students with and without FHP. **Methods**: One hundred and twenty-one healthy, college-aged participants were divided into groups of good (n=56) and bad posture (n=65). Participants with a craniovertebral angle of ≤50° were categorized as having bad posture. Psychological patient-rated outcome measures were then collected using the Neck Disability Index (NDI), General Anxiety Disorder-7 (GAD-7), Dispositional Positive Emotion Scale – Pride subscale (DPES), and the Patient-Reported Outcome Measurement Information System-29 (PROMIS-29). Physical measurements including scapular index, shoulder range of motion, and deep cervical flexor endurance (DCFE) were also assessed. Outcome data were analyzed using Mann-Whitney U tests with alpha set at 0.05. **Results**: The bad posture group had worse measures in multiple categories including: NDI (p=0.02), PROMIS-29 scores for Anxiety (p=0.002), Fatigue (p=0.001), Sleep Disturbance (p=0.01), and Satisfaction with Social Role (p=0.05). There were no differences in RSP or DCFE performances between groups. Only left shoulder flexion (p=0.05) was less in the bad posture group. **Conclusion**: Bad posture, as measured by presence of FHP, demonstrated more adverse psychological outcomes as determined by the various patient-rated scales. Although significance

was not reached in many outcomes, a definitive negative trend was seen in all physical and psychological assessments within the FHP group.

Introduction:

Posture and good health have been connected and studied for centuries as illnesses were often linked to the hazard of bending over to read and write because of poor lighting or furniture.[1] Even though the use of computers and cell phones have changed how we manage and process information, there have not been changes to the adoption of poor posture to accomplish tasks associated with daily living. Reading a screen often requires people to alter the position of their head, neck, and shoulders and this is commonly referred to as “text neck”.[2,3] Text neck is typically characterized by a forward head posture (FHP) where the head sits forward of the spinal column and a rounded shoulder posture (RSP) where the shoulders roll inward creating a hunched back.

FHP affects an estimated 61-85% of individuals [4-8] and is primarily caused by underactivity of the deep cervical flexors and presents with an anterior protrusion of the head in addition to excessive cervical extension. RSP is caused by overactivity in the muscles responsible for humeral internal rotation, scapular elevation and anterior tipping: the pectoralis major, pectoralis minor, latissimus dorsi, subscapular, levator scapulae, and upper trapezius. RSP is often coupled with FHP [9-15] and is referred to as “upper cross syndrome”[16]. Measurement of FHP has been well validated and replicated with the craniovertebral angle (CVA) technique,[17,18] but no such measure has been consistently validated for measuring RSP. Even though the CVA technique is the gold standard for measuring FHP, no specific angle measurement has been identified for the classification of FHP. However, a cutoff angle of ≤50° has been used previously in the literature.[19-21]

FHP has been etiologically linked to a multitude of dysfunctions including temporomandibular joint dysfunction syndrome [22-24], thoracic outlet syndrome [25], cervical and lumbosacral radiculopathy [20,26], and chronic neck pain [6,27-30]. Posture has also been associated with body language and nonverbal communication. Nonverbal communication literature identifies specific postural presentations denoting various psychological traits. Mehrabian [31] found that stooped and contractive postures, like FHP and RSP, can be indicative of submission and subordination in individuals. Gifford [32] also confirmed these suspicions by noting that dominant-ambitious individuals displayed less forward head tilt compared to submissive individuals. Research by Ramezanzade and Arabnarmi [33] found a moderate negative relationship between self-esteem and RSP, but no relationship between self-esteem and FHP. Coulson [34] demonstrated that socially, sadness was the only emotion that is depicted by FHP. Therefore, both FHP and RSP seem to be associated with more negative emotions and affects. However, to date, these are the only studies that have linked emotions to FHP and RSP, indicating that these postures may play a central role in the expression of emotion or the cause of emotion.

College is a pivotal time for young individuals to position themselves for the future but it is also often marked by mental health challenges due to life stresses.[35-38] College also places young adults in situations where work on computers and the use of cell phones precipitates poor posture like “text neck”.[2,39-42] Therefore, the primary aim of this study was to investigate the link between FHP and psychological measures as measured by several patient-rated outcome scales in a college-aged population. We hypothesized that individuals with FHP would have more neck pain and would exhibit altered psychological scores as measured by components of the Neck Disability Index (NDI), General Anxiety Disorder – 7 (GAD-7), Dispositional Positive Emotion Scale – Pride (DPES), and the patient-rated outcome measurement information system (PROMIS-29).

Materials and Methods:

Study Design

The research design was a single blind observational study to compare subjects that classified as FHP with a CVA angle of less than 50 degrees and subjects that did not classify as FHP. A power analysis using alpha = 0.05 and ß = 0.80 determined that at least 45 subjects were needed for each group. Dependent variables included subjective measures designed to assess pain, anxiety, daily limitations, and emotions and objective assessments included CVA, scapular index, shoulder flexion, internal and external range of motion, and cervical neck extensor endurance. The study was approved by the Institutional Review Board at the University and study participants electronically signed an informed consent before any questionnaires or physical measures were taken.

Subjects

To be eligible, participants were required to not be currently taking medication for anxiety and/or depression and needed to be apparently healthy without any physical impairments (i.e., acute or chronic musculoskeletal injury) that would impede potential exercise requirements. Participants were not competitive athletes, had no surgical history to the upper body, head, neck, back or upper extremities, and were not currently pregnant. Participants were also excluded if they had a history of cervical fractures, stenosis, disk herniation, any neurological symptoms to the upper body, or had a history of cervical or brachial nerve related injury, suffered from vertigo or inner ear issues.

A total of 121 participants (males: n=66; females: n=55) were recruited from the university population who were aged between 18 and 26 using a combination of research flyers, face-to-face, and email recruitment. Prior to recruitment, researchers established that subjects would be placed into one of two groups based on FHP as determined by CVA. Subjects were placed into the FHP group if they had a CVA of less than 50 degrees based on the literature.[19-21] Demographics for each group are presented in Table 1. The only significant difference between posture groups was body mass ($t_{(117)}$=-2.01; p=0.47). The bad posture group had a higher body mass. This larger body mass is not reflected by a statistically significant difference in exercise participation as measured by the Tegner Activity Scale. All other measures had no statistically significant difference between the two groups, highlighting the homogeneity of the participants.

Table 1. Demographic Data for Both Posture Groups.

Mean (SD)	Bad Posture (n=65)	Good Posture (n=56)	Total (n=121)
Age	21.2 (2.3)	20.8 (1.9)	21.0 (2.2)
Height (cm)	168.8 (10.0)	171.6 (10.0)	170.1 (10.1)
Weight (kg)	76.2 (17.3)	70.6 (13.3)	73.6 (15.9)
Tegner Activity Scale	3.4 (2.4)	3.9 (2.7)	3.6 (2.5)

Procedures

Survey

Upon arrival at the laboratory, participants were asked to scan a QR code and use their own personal devices to access the QuestionPro system, which is an anonymous survey system that is compliant according to General Data Protection Regulations. This survey took participants an average of 19 minutes to complete and contained demographic questions, the Neck Disability Index (NDI), the General Anxiety Disorder-7 scale (GAD7), the Dispositional Positive Emotion Scale – Pride subscale, and portions of the Patient-Reported Outcomes Measurement Information System (PROMIS-29).

Posture Assessment

For measurement of RSP and FHP, two primary methods were used including Scapular Index (SI) and CVA. SI involves using a tape measure to measure the distance between two landmarks on the anterior (A) and posterior (P) of the participant's body (Figure 2 a, b). A is then divided by P and multiplied by 100 for a percentage. Scapular Index is an acceptable assessment.[43,44] CVA is a validated and reliable method of measuring FHP posture[17,18,45] and, thus, was the method used to categorize participants into either ‘good’ or ‘bad’ posture groups. Participants qualified as good posture if a CVA of less than or equal to 50° was determined. In order to measure CVA, reflective motion capture markers were used to identify the tragus, C7, sternal notch, acromion process landmarks as these markers would appear white when camera flash was used (Figure 1). We measured CVA using a Google Pixel 6 phone camera to capture a sagittal view of the participant’s left side while standing. The participant was asked to look forward at a comfortable height, before being instructed to close their eyes. Generic conversation was used for distraction before the photograph was taken. Photographs were taken landscape and parallel to the floor before being processed using Kinovea (Version 0.8.15). This free software has been shown to be a valid and reliable tool[46-48] and it was used to calculate the angle from the seventh cervical vertebrae to the tragus of the ear.

Figure 1. Craniovertebral Angle Measurement. Reflective motion capture markers on the C7 vertebrae and the tragus of the ear. C7 = seventh cervical vertebrae.

Physical Measurements

Passive Shoulder Range of Motion

Passive shoulder range of motion (ROM) measurements (Figure 2 c, d, e) were taken by principal investigator and one of two trained co-investigators using a spirit bubble level goniometer (RehabMart.com; Watkinsville, GA), which followed standard procedures for the measurement of ROM. The spirit bubble level and investigator scapular stabilization ensured reliability of measurements.[49] Participants lay supine on a table and principal investigator stabilized the scapula and moved the arm to obtain end range positions, while co-investigators measured the joint range of motion. Shoulder internal and external rotation, as well as flexion were measured on both the right and left arm. For internal and external ROM, a bolster was used to support the upper arm. The primary research personnel stood at the head of the participant and placed their support hand underneath the scapula with their palm pushing on the spine of the scapula to gauge movement and compensation for the passive ROM. The participant's arm was then moved to end range internal and external ROM as determined by compensation and lift of the scapula in the research personnel's hand. The other research personnel then measured the range of motion with the stationary arm of the goniometer vertical (according to the spirt level bubble), and the moveable arm tracking the participant's ulna. Shoulder flexion measured true glenohumeral flexion ROM through stabilization of the scapula. The primary research personnel stood beside the participant and placed their hand on the lateral border of the scapula. The arm was then moved into maximal shoulder flexion as measured by the scapula pushing into the research personnel's hand which indicated compensation of the scapula. The measuring research personnel placed the goniometer at the shoulder joint with the stationary arm aligning with the torso of the participant as measured by the spirit level bubble. The moveable arm then followed the path of the participant's humerus. All shoulder ROM measures were recorded by the measuring research personnel onto a piece of paper, blinded to the primary research personnel until data input.

Deep Cervical Flexor Endurance Test

The participant was instructed to lay supine on a treatment table and told to squeeze their chin as if they were to "squeeze an orange between their chin and chest", before lifting the head off the table to maintain the position (Figure 2 f). Once this position was established a stopwatch began and form was monitored.

The measuring personnel placed two fingers underneath the participant's head to ensure head was maintained at correct height. Research monitored the maintenance of a chin tuck and head position throughout the test. The participant was instructed to hold the position as long as they could or, if participant was unable to correct any deviations in position, the assessment was concluded.

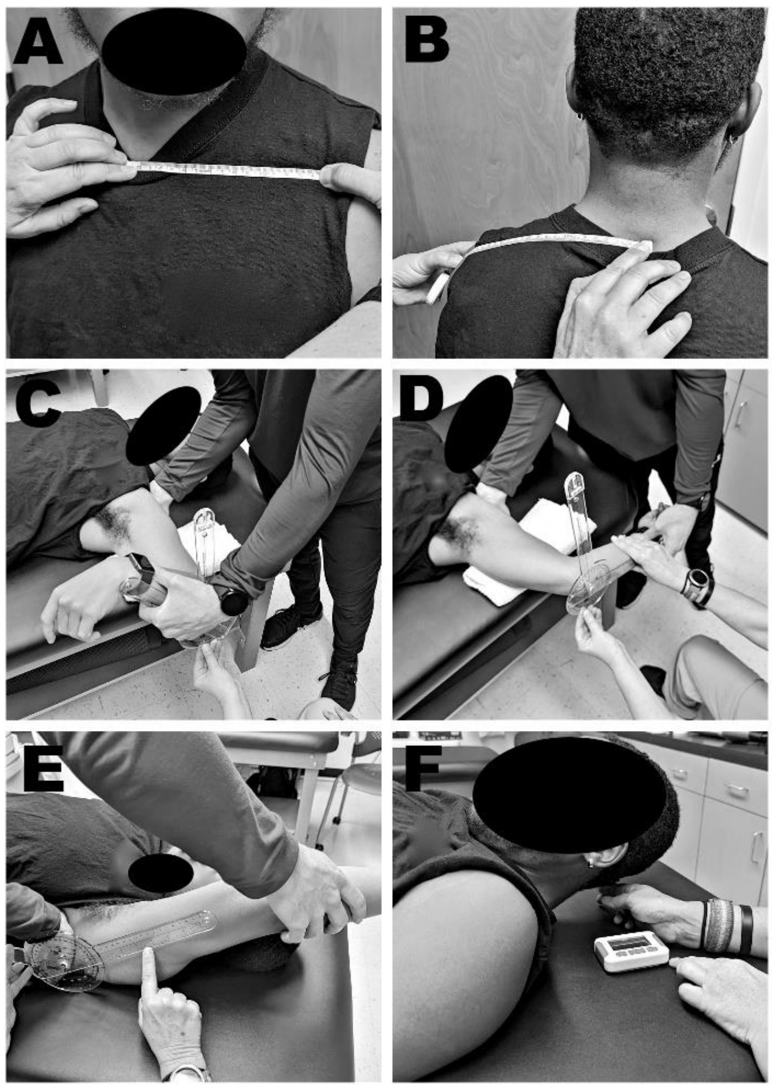

Figure 2. Physical Measurements Procedures. a) anterior measure of SI – sternal notch to coracoid process, b) posterior measure of SI – C7 to posterior lateral acromion, c) shoulder internal rotation, d) shoulder external rotation, e) shoulder flexion, f) deep cervical flexor endurance test. SI = scapular index, C7 = seventh cervical vertebrae.

Scoring of the Patient-Rated Outcome Measures

The NDI consists of 10 questions pertaining to neck pain and disability and can be scored from 0 (no pain/disability) to 5 (maximal pain or inability to perform task), and has been shown to be valid and reliable. The 10 questions are cumulatively scores to provide a final disability rating score categorized as: no disability, mild disability, moderate disability, severe disability, or completely disabled. The GAD-7 asks 7 questions about feelings of anxiety over the past two weeks, and these questions are scored from 0 (not at all) to 3 (nearly every day) for a cumulative total. Anxiety severity is then categorized for the final scores as either minimal, mild, moderate, or sever anxiety. The DPES scale asks 5 questions relating to an individual's self-reported feelings of pride on a scale of 1 (strongly disagree) to 7 (strongly agree), to which the average response of the 5 questions is scored. This specific subscale of the larger DPES was chosen as many of the questions relate specifically to some of the nonverbal communication and psychology observations seen regarding posture. The PROMIS-29 (Version 1.0) was developed to measure non-specific health-related domains of a variety of outcomes to score individuals from 1 to 5 with 1 being the most severe of symptoms or function loss. Scores are then sent into an online database and presented as T-scores based upon the population average. This study compared participants to a general adult population using the HealthMeasures Scoring Service default calibration sample. Resultant scores are then compared to a population average with 50 being the mean score for that population (Figure 4).

Statistical Analysis

Data is presented with mean ± standard deviation. The distributions were not normal, therefore we used a Mann-Whitney U to calculate the significant differences between the posture groups. To determine the magnitude and meaningfulness of the findings, effect size statistics were calculated using Cohen's *d*, with the size of effect categorized as small (from 0.2 to 0.5), medium (from 0.5-0.8), or large (over 0.8). All data were analyzed using SPSS version 28.0 (SPSS Inc., Chicago, IL, USA) for Windows. The level of significance was established at an alpha level equal to 0.05.

Results

Physical Measures

Table 2 indicates differences in physical measurements. As groups were split according to CVA with participants having a measurement of 50° or less classifying as "bad" posture, a significant difference for CVA was seen ($p<0.000$). No statistically significant differences were found for the SI measurement or the DCFE test. Of the shoulder ROM measurements, only left shoulder flexion scored a statistically significant t score.

Table 3 indicates the differences in the patient-rated outcome scores measured which consisted of the NDI, GAD-7, DPES-Pride, and the various components of the PROMIS-29. Statistically significant differences were found between groups for the NDI ($p=0.02$), and the Anxiety ($p=0.002$), Fatigue ($p=0.01$), Sleep ($p=0.01$), and Satisfaction ($p=0.05$) scales for the PROMIS-29 measures. It should be noted that the PROMIS-29 depression subscale was omitted from this study.

Table 2. Physical Measurements Values for Both Posture.

Total (n=161)	**Bad Posture (n=65) Mean ± SD (95% CI)**	**Good Posture (n=56) Mean ± SD (95% CI)**	**p-value**	**Cohen's d (95% CI)**
CVA (Degrees)	44.1 ± 4.7 (42.9-45.3)	54.8 ± 3.6 (53.8-55.8)	.000**	2.5 (2.1-3.0)
SI (%)	70.1 ± 5.5 (68.7-71.5)	70.4 ± 5.9 (68.8-72.0)	.88	0.04 (-0.32-0.40)
DCFE (sec)	53.8 ± 27.4 (53.0-54.6)	61.5 ± 33.8 (60.3-62.7)	.32	0.25 (-0.11-0.61)
Left IR	35.1 ± 12.4 (32.0-38.2)	32.7 ± 12.0 (29.5-35.9)	.43	-0.20 (-0.55-0.16)
Right IR	30.7 ± 14.5 (27.1-34.3)	28.2 ± 13.1 (24.7-31.7)	.31	-0.18 (-0.54-0.18)
Left ER	105.3 ± 11.7 (102.4-108.2)	107.1 ± 11.4 (104.0-110.2)	.73	0.15 (-0.21-0.51)
Right ER	108.2 ± 11.7 (105.3-111.1)	110.1 ± 11.8 (106.9-113.3)	.64	0.16 (-0.20-0.52)
Left Total Rotation	140.4 ± 18.7 (140.4-135.6)	139.7 ± 16.0 (135.4-144.0)	.93	-0.04 (-0.40-0.32)
Right Total Rotation	138.9 ± 18.5 (134.3-143.5)	138.3 ± 18.4 (133.4-143.2)	.96	-0.03 (-0.39-0.33)
Left FLX	149.5 ± 9.6 (147.1-151.9)	153.4 ± 12.6 (150.0-156.8)	.05*	0.36 (-0.01-0.71)
Right FLX	148.3 ± 10.1 (145.8-150.8)	149.9 ± 12.4 (146.6-153.2)	.40	0.14 (-0.22-0.50)

CVA = craniovertebral angle, SI = scapular index, IR = internal rotation, ER = external rotation, FLX = flexion.

Table 3. Patient-Rated Outcome Scores Values for Both Posture Groups

Total (n=161)	Bad Posture (n=65) Mean ± SD (95% CI)	Good Posture (n=56) Mean ± SD (95% CI)	p-value	Cohen's d (95% CI)
NDI (Score)	2.4 ± 3.1 (1.6-3.2)	1.3 ± 1.9 (0.8-1.8)	.02*	-0.44 (-0.79- -0.07)
GAD-7 (Score)	3.7 ± 4.1 (2.7-4.7)	2.2 ± 2.5 (1.5-2.9)	.07	-0.42 (-0.78- -0.06)
DPES-Pride (Score)	5.4 ± 1.1 (5.1-5.7)	5.6 ± 1.0 (5.3-5.9)	.54	0.16 (-2.0-0.52)
PROMIS-29 – PHYS	55.8 ± 3.3 (55.0-56.6)	56.2 ± 2.4 (55.6-56.8)	.45	0.16 (-0.20-0.52)
PROMIS-29 – ANX	52.4 ± 8.9 (50.2-50.6)	47.4 ± 7.9 (45.3-49.5)	.002*	-0.60 (-0.96- -0.23)
PROMIS-29 – FAT	48.6 ± 8.9 (46.4-50.8)	43.4 ± 8.5 (41.1-45.7)	.01*	-0.60 (-0.96- -0.23)
PROMIS-29 – SLEEP	49.4 ± 8.7 (47.3-51.5)	45.3 ± 7.4 (43.3-47.3)	.01*	-0.50 (-0.86- -0.14)
PROMIS-29 – SATIS	52.3 ± 8.4 (50.2-54.4)	55.3 ± 8.0 (53.2-57.4)	.05*	0.37 (0.01-0.73)
PROMIS-29 – PAIN	45.7 ± 5.7 (44.3-47.1)	44.0 ± 4.8 (42.7-45.3)	.07	-0.31 (-0.67 - 0.05)

NDI = neck disability index, GAD-7 = general anxiety disorder-7, DPES = dispositional positive emotion scale – pride subscale, PROMIS-29 = patient-reported outcome measurement information systems – 29, PHYS = Physical Functioning, ANX = Anxiety, FAT = Fatigue, SLEEP = Sleep Disturbance, SATIS = Satisfaction with Social Role.

In summary, this set of findings indicate statistically significant differences among groups in multiple patient-rated outcome measures, with the effect size ranging from small to medium as measured by the Cohen's *d*.

Discussion

This study is unique in that by categorizing individuals as good and bad posture (as measured by CVA), we were able to compare physical and psychological measures between the two group designations. None of our participants had any acute or chronic musculoskeletal conditions and were not diagnosed with either anxiety or depression. The primary aim of this study was to investigate the link between FHP and psychological measures in a college-aged population. We were able to find differences in psychological outcomes between the two groups.

Regarding the psychological and functional outcome scores, significance within t-scores was found with four components of the PROMIS-29, and the NDI. Cohen's *d* measured the effect size based upon the differences between the means, to which a small effect size is considered 0.2 and a medium is 0.5.[50] PROMIS-29's Anxiety, Fatigue, and Sleep ranked as medium, with NDI and PROMIS-29 Satisfaction scored small-medium effect sizes. Previous studies have shown the link between FHP and NDI score,[28,30,51] so this relationship was to be expected, but the psychological outcome measures show a deeper connection between mind and body, which is termed embodied cognition.[52] Emphasizing that this participant pool was asymptomatic in both psychological and physical senses as determined from our inclusion and exclusion criteria, and still yielded these substantial effect sizes relating to posture, further illustrates the inherent link between the mind and body.

It had been reported that FHP and RSP are often seen in conjunction,[13] but our findings do not support previous research as no significant difference between the two groups for SI. Both groups reported similar amounts of total rotational ROM on both sides, however, the bad posture group tended to have more internal rotation and less external rotation than the good posture group. These findings could be expected to be observed if significant differences in SI were present as the RSP is displayed with an increase in shoulder internal rotation from a resting posture, suggesting that FHP may alter shoulder kinematics. This finding was consistent with those from Shin et al. [51]

This study provided small to moderate effect sizes for the relationship between FHP and various psychological outcomes. A strength of the study was the moderate effect sizes for the significant PROMIS-29 scales including Anxiety, Fatigue, Sleep, and Satisfaction in Social Role, all of which reached significance. Based upon the nonverbal communication literature findings,[31] the questions asked in the DPES-Pride subscale were thought to be very pertinent to postural outcomes, but this effect size was small and not significant. If the study were to be repeated, adding the depression section of the PROMIS-29 would be a key addition to investigate the links between posture and depressive symptoms given the literature (CITE). Another limitation was devoting more time to ensure training of research personnel and therefore consistency of measurement techniques regarding the DCFE test. Previous research found a link between FHP decreasing neck strength endurance,[53,54] but our findings saw no statistically significant difference between the two groups.

This study demonstrated that body posture, as measured by FHP, can be used predictively for psychological measures related to anxiety, sleep quality, fatigue, overall satisfaction, and neck function. Knowing that the findings from this study support those found previously,[55-58] it provides a promising foundation for subsequent research. Future investigations could be taken in one of two ways – rehabilitating these "bad" postures and investigating the psychological changes associated with a change in FHP, and to repeat the study with patient populations who have been diagnosed with pathologies such as anxiety or chronic fatigue. Although no relationship between FHP and RSP was found, shoulder ROM biases between internal and external ROM demonstrate the impact head posture has on shoulder kinematics. Further validation of RSP measures is needed before methods such as SI can be accurately relied upon.

Conclusions

Our study supports previous nonverbal communication literature that the mind and body are inherently linked, and not separate from one another. There was a clear difference in psychological outcomes between the groups, with bad posture participants having more anxiety, more fatigue, worse sleep, and less satisfaction with their social role when compared to those with good posture. These results provide a foundation for further research into the relationship between posture and psychology, and provide the impetus for an investigation on changes in psychological state resulting from different postural rehabilitation protocols.

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CHAPTER 5

INVESTIGATION INTO THE PHYSICAL AND PSYCHOLOGICAL ADAPTATIONS TO A NEUROMUSCULAR INTEGRATION APPROACH TO REHABILITATING FORWARD HEAD POSTURE IN COLLEGE-AGED STUDENT

Introduction

Daily living and sedentary lifestyle habits have negatively impacted our posture in recent times. The increased use of computer and mobile phones has resulted in negative postural adaptations to our head and shoulders which impact anywhere from 60 to 85% of individuals.[1-5] Musculoskeletal literature refers to this as forward head posture (FHP)[6] and rounded shoulder posture (RSP),[7] but colloquially it is known as "text neck".[8,9] FHP presents with an anterior protrusion of the head resulting from underactivity of the deep cervical flexors. While RSP is typified with an upward and anterior rolling of the shoulders forward and glenohumeral internal rotation. FHP can lead to temporomandibular joint dysfunction syndrome,[10-12] cervicogenic headaches,[13] and chronic neck pain,[14-18] while RSP can increase the risk of developing subacromial impingement,[19-21] thoracic outlet syndrome,[22-25] and abnormal scapulohumeral rhythm.[19,22,26]

Previous research in nonverbal communication and psychology have investigated the relationship between mind and body, referred to as embodied cognition.[27-29] Stooped, contractive body postures that typify FHP and RSP have been shown to denote submission and subordination,[30] as the individual attempts to appear smaller, which in turn negatively affects confidence, memory recall, stress, and emotional health. In contrast, wide, expansive gestures, less FHP, and erect postures are evident in those who symbolize power and dominance.[30,31] More recently, sadness and depression have been attributed to individuals who display FHP and increased thoracic kyphosis,[32-35] with such emotions negatively impacting muscle tonicity.[36-40]

Rehabilitation of these postural dysfunctions have typically utilized exercises that only strengthen one specific muscle in isolation. Neuromuscular integration (NI) approaches have become common practice in lower extremity rehabilitation for anterior cruciate ligament (ACL) and lateral ankle sprain rehabilitation,[41-46] with comparatively less research on upper body postural dysfunction. The limited research on rehabilitating FHP and RSP with a NI approach has demonstrated positive results for the FHP when compared to traditional approaches.[47]

Similarly, the measurement of postural dysfunction varies in its approach. FHP utilizes craniovertebral angle (CVA) which uses a lateral photograph of a participant to measure the perpendicular angle from the seventh cervical (C7) vertebrae to the tragus of the ear, which has shown to be valid and reliable.[48,49] However, classification of FHP based upon this angle lacks reliability according to Sheikhhoseini et al. [6], with 50° being considered a common cutoff point.[50-52] Conversely, RSP measurement is greatly contested with measurement techniques utilizing a mixture of standing and supine positions to accurately assess the posture.[53] Scapular Index (SI) has been used in previous studies,[54-57] but no technique has the universal agreement that CVA currently has.[54]

College-aged adults are of particular interest to researchers and clinicians due to the prevalence of mental health issues within this population,[58-60] and due to the large amount of screen time they experience from cell phones and computer requirements. Therefore, knowing the link between psychology and posture, the primary aim of this study was to investigate the effect of NI rehabilitation techniques on the treatment of FHP and psychological outcomes as recorded by a variety of patient-rated outcome scales. We hypothesized that if FHP improves through NI rehabilitation, there will also be an improvement in psychological patient-rated outcome scales as measured by components of the patient-rated outcome measurement information system (PROMIS-29), General Anxiety Disorder – 7 (GAD-7), Dispositional Positive Emotion Scale – Pride (DPES), and Neck Disability Index (NDI).

Materials and Methods

Study Design

The research design was a single blind intervention study to investigate postural and psychological improvement over the course of an 8-week exercise intervention in subjects with FHP. Subjects were randomly allocated into 1 of 3 exercise protocols: an intervention group focused on correcting FHP, a general exercise group, and a control group. Dependent variables included patient-rated outcome measures to assess pain, anxiety, daily limitations, and emotions and objective assessments of posture and movement included CVA, scapular index, shoulder flexion, internal and external range of motion, and cervical neck extensor endurance. Exercises were to be completed 3 times per week, for 8 weeks. Assessment was conducted at the 0- and 9-week marks to signify pre and post measures, with a 4- week appointment implemented to ensure compliance and reduce attrition. The study was approved by the Institutional Review Board at the University and study participants electronically signed an informed consent before any questionnaires or physical measures were taken.

Subjects

To be eligible, participants were required to have a CVA measurement of 50° or less, which was the FHP cutoff used in previous studies.[50-52] Participants also could not be currently taking medication for anxiety and/or depression and needed to be apparently healthy without any physical impairments (i.e., acute or chronic musculoskeletal injury) that would impede potential exercise requirements. Participants were not allowed to be specialist or competitive athletes, or have surgical history of the upper body, head, neck, back or upper extremities, and were not currently pregnant. Exclusion criteria specified removal of participants if they had a history of cervical fractures, stenosis, disk herniation, any neurological symptoms to the upper body, or had a history of cervical or brachial nerve related injury, suffered from vertigo or inner ear issues. A total of 65 participants (males: n=32; females: n=33) aged between 18 and 26 were recruited to account for attrition. They were recruited using combination of research flyers, face-to-face contact, and email recruitment. Exercise allocation group was randomized, and allocation was blinded to the participant and the measurement personnel. Only the primary researcher knew of allocations. Table 1 shows the demographic data for the participants. The power analysis used an alpha = 0.05, ß = 0.80, and an effect size of 0.25 to determine that a minimum of 12 subjects were needed for each group.

Table 1. Demographic Data for All Exercise Groups

Mean (SD)	Intervention (n=13)	General Exercise (n=13)	Control (n=14)	Total (n=40)
Age	21.3 (1.7)	21.4 (2.8)	21.8 (3.0)	21.5 (2.5)
Height (cm)	168.6 (9.3)	169.0 (8.9)	165.8 (10.0)	167.8 (9.3)
Weight (kg)	80.8 (21.6)	74.9 (15.4)	73.6 (20.6)	76.4 (19.2)
BMI	28.2 (6.3)	26.1 (4.2)	26.5 (5.1)	26.9 (5.2)
Tegner Activity Scale	4.9 (2.2)	4.2 (3.0)	3.6 (1.8)	4.3 (2.4)

Procedures

Questionnaires

Upon arrival at the laboratory, participants were asked to scan a QR code and use their own personal devices to access the QuestionPro system, which is an anonymous survey system that is compliant according to General Data Protection Regulations. The QuestionPro form took participants an average of 19 minutes to complete for initial visits, and 6 minutes for subsequent visits. The form contained demographic questions, the Neck Disability Index (NDI), the General Anxiety Disorder-7 scale (GAD7), the Dispositional Positive Emotion Scale – Pride subscale (DPES), and portions of the Patient-Reported Outcomes Measurement Information System (PROMIS-29).

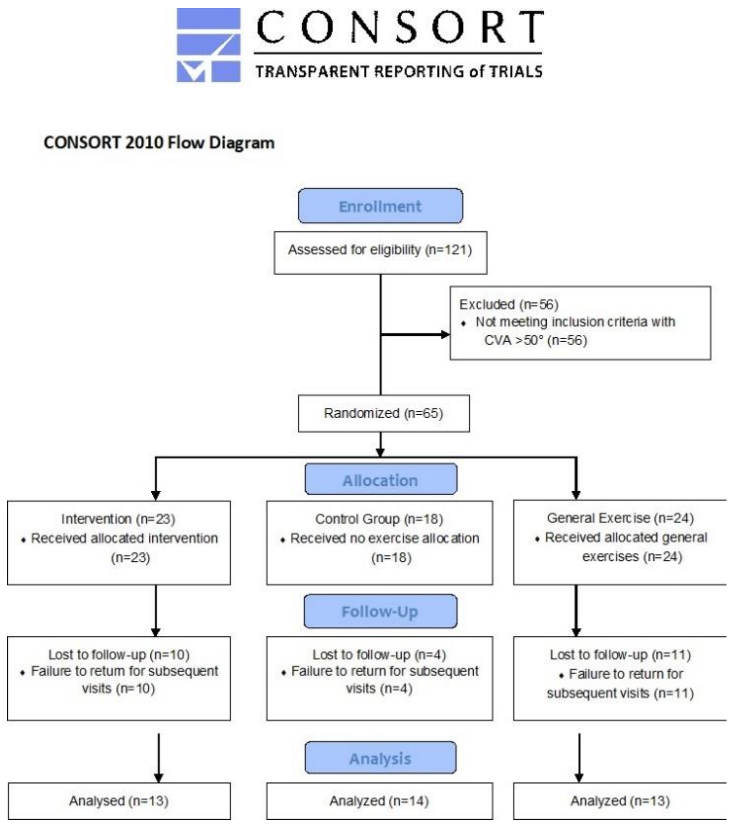

Figure 1. CONSORT diagram indicating participant participation and attrition.

Posture Assessment

For measurement of FHP and RSP, two primary methods were used. The included CVA and Scapular Index (SI). CVA is a validated and reliable method of measuring FHP posture[48,49,61] and, thus, was the method used to categorize participants into either 'good' or 'bad' posture groups. Participants qualified as good posture if a CVA of less than or equal to 50° was determined. In order to measure CVA, reflective motion capture markers were used to identify the tragus, C7, sternal notch, and acromion process landmarks. These markers would appear white when a camera flash was used (Figure 2). We measured CVA using a Google Pixel 6 phone camera to capture a sagittal view of the participant's left side while standing. The participant was asked to look forward at a comfortable height, before being instructed to close their eyes. Generic conversation was used for distraction before the photograph was taken.

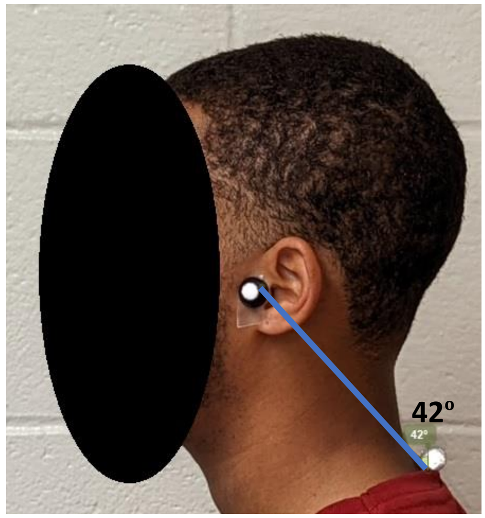

Figure 2. Craniovertebral angle measurement. Reflective motion capture markers on the C7 vertebrae and the tragus of the ear. C7 = seventh cervical vertebrae.

Photographs were taken landscape and parallel to the floor before being processed using Kinovea (Version 0.8.15). This free software has been shown to be a valid and reliable tool[62-64] and it was used to calculate the angle from the seventh cervical vertebrae to the tragus of the ear from vertical, this resultant angle was then subtracted from 90 degrees to get a true CVA measurement from horizontal. SI involves using a tape measure to measure the distance between two landmarks on the anterior (A) and posterior (P) of the participant's body (Figure 3a, b). A is then divided by P and multiplied by 100 for a percentage. Scapular Index is an acceptable assessment for measurement of RSP.[54,65]

Physical Measurements

Passive Shoulder Range of Motion

Passive shoulder range of motion (ROM) measurements (Figure 3c, d, e) were taken by the principal investigator and one of two trained co-investigators using a spirit bubble level goniometer (RehabMart.com; Watkinsville, GA), which followed standard procedures for the measurement of ROM. The spirit bubble level and investigator scapular stabilization ensured reliability of measurements.[66] Participants lay supine on a table and the principal investigator stabilized the scapula and moved the arm to obtain end range positions, while co-investigators measured the joint range of motion. Shoulder internal and external rotation, as well as flexion were measured on both the right and left arm. For internal and external ROM, a bolster was used to support the upper arm. The primary researcher stood at the head of the participant and placed their support hand underneath the scapula with their palm pushing on the spine of the scapula to gauge movement and compensation for the passive ROM. The participant's arm was then moved to end range internal and external ROM as determined by compensation and lift of the scapula in the research personnel's hand. The other researcher then measured the range of motion with the stationary arm of the goniometer vertical (according to the spirt level bubble), and the moveable arm tracking the participant's ulna. Shoulder flexion measured true glenohumeral flexion ROM through stabilization of the scapula. The primary researcher stood beside the participant and placed their hand on the lateral border of the scapula. The arm was then moved into maximal shoulder flexion as measured by the scapula pushing into the research personnel's hand, which indicated compensation of the scapula. The measuring researcher placed the goniometer at the shoulder joint with the stationary arm aligning with the torso of the participant as measured by the spirit level bubble. The moveable arm then followed the path of the participant's humerus. All shoulder ROM measures were recorded by the measuring researcher onto a piece of paper, blinded to the primary researcher until data input.

Deep Cervical Flexor Endurance Test

The participant was instructed to lay supine on a treatment table and told to squeeze their chin as if they were to "squeeze an orange between their chin and chest", before lifting the head off the table to maintain the position (Figure 3f). Once this position was established a stopwatch began and form was monitored. The measuring personnel placed two fingers underneath the participant's head to ensure head was maintained at correct height. Researchers monitored the maintenance of a chin tuck and head position throughout the test. The participant was instructed to hold the position for as long as they could or, if the participant was unable to correct any deviations in position, the assessment was concluded.

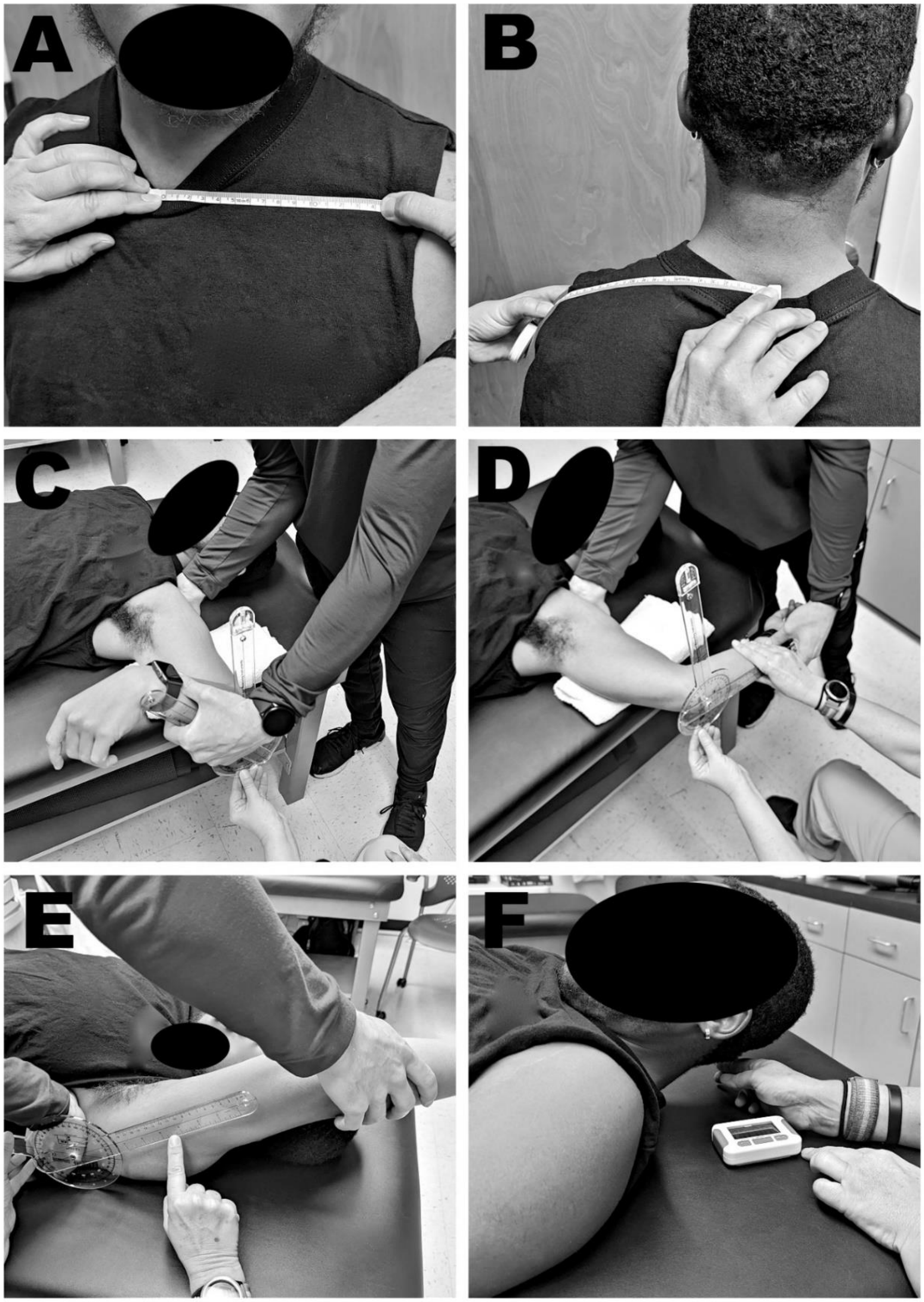

Figure 3. Physical measurements. a) anterior SI, b) posterior SI, c) shoulder internal rotation, d) shoulder external rotation, e) shoulder flexion, f) deep cervical flexor endurance test.

Scoring of the Patient-Rated Outcome Measures

The NDI consists of 10 questions pertaining to neck pain and disability and can be scored from 0 (no pain/disability) to 5 (maximal pain or inability to perform task), and has been shown to be valid and reliable. The 10 questions are cumulatively scores to provide a final disability rating score categorized as: no disability, mild disability, moderate disability, severe disability, or completely disabled. The GAD-7 asks 7 questions about feelings of anxiety over the past two weeks, and these questions are scored from 0 (not at all) to 3 (nearly every day) for a cumulative total. Anxiety severity is then categorized for the final scores as either minimal, mild, moderate, or sever anxiety. The DPES scale asks 5 questions relating to an individual's self-reported feelings of pride on a scale of 1 (strongly disagree) to 7 (strongly agree), to which the average response of the 5 questions is scored. This specific subscale of the larger DPES was chosen as many of the questions relate specifically to some of the nonverbal communication and psychology observations seen regarding posture. The PROMIS-29 (Version 1.0) was developed to measure non-specific health-related domains of a variety of outcomes to score individuals from 1 to 5 with 1 being the most severe of symptoms or function loss. Scores are then sent into an online database and presented as T-scores based upon the population average. This study compared participants to a general adult population using the HealthMeasures Scoring Service default calibration sample. Resultant scores are then compared to a population average with 50 being the mean score for that population (Figure 4).

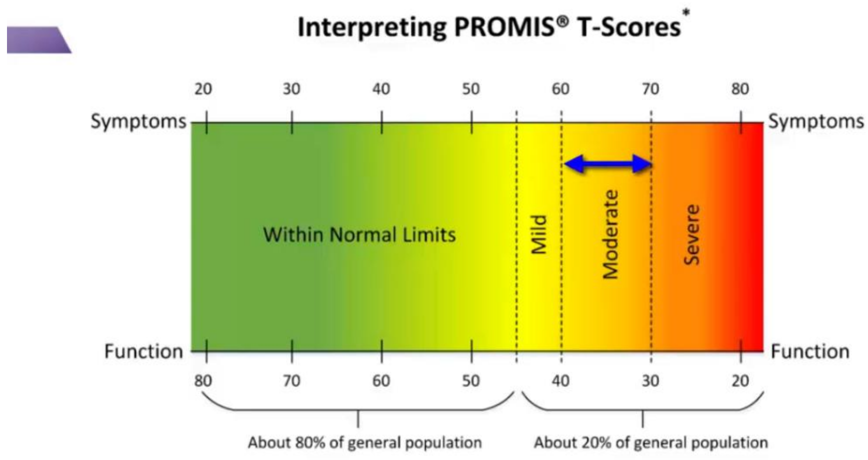

Figure 4. PROMIS-29 scoring system interpretation

Exercise Interventions

One of three exercise interventions were assigned to participants based on random allocation blinded to participants and the measurement personnel. The treatment intervention group consisted of exercises that focused on rehabilitating FHP using a NI approach (Figure 5A, B, and C), while the general exercise group performed generic exercises that neither improved nor worsened the participant's posture (Figure 6A, B, and C). A final control group was not required to complete any exercise over the 8-week intervention period. This random allocation was performed using Microsoft Excel.

Each exercise protocol took approximately 20-30 minutes to complete, 3 times per week, and included warm-up, stretching, and strengthening components. Exercises were distributed over the QuestionPro server, and annotated videos and written descriptions were used to disseminate the exercises and maintain form. Participants were encouraged to contact the primary researcher if they had questions. Exercises were divided into 3 phases similar to phases outlined by

Bayattork et al. [5]: Initial (2 weeks), Improvement (4 weeks), and Maintenance (2 weeks). The initial phase introduced the exercises and kept intensity low to allow exercise tolerance to build. The improvement and maintenance stages contained the same exercises, aiming to increase the intensity and complexity of exercises.

The warm-up for both exercise groups consisted of 10 repetitions of arm circles in each direction, 10 jumping jacks, and 30 seconds of high knees. Stretches were instructed to performed at an intensity to which the individual felt a stretching sensation without the presence of pain or alterations in breath, with an emphasis on sinking deeper into the stretch on each exhale. Treatment stretches were more dynamic and loaded in nature, while the general exercise group performed mostly static stretches. Exercises required no equipment except for resistance bands which were provided by research personnel. These exercises were prescribed so that individuals would complete 12-20 repetitions with the aim of improving the repetition number each performance. Exercises for the treatment and general exercise groups are detailed in Figures 5A, 5B, 5C, 6A, 6B, 6C. Exercise descriptions are listed in Appendix 1A-2B.

Intervention group exercises. The initial phase for the intervention group consisted of the following stretches (Figure 5A) i) Hamstring, ii) Thoracic Rotation, iii) Hip Flexors, iv) Pectoralis Major/Minor, v) Upper Trapezius, vi) Levator Scapulae, vii) Thoracic Extension, and vii) Piriformis. Initial stage exercises (Figure 5B) included i) I's and T's, ii) No Moneys, iii) Single Leg Balance, iv) Bridges, v) Floor Pushups, vi) Dead Bugs, and vii) Banded Chin Tucks. The improvement phase exercises included stretches (Figure 5A) with the addition of a more aggressive deep lunge stretch for the hip flexors. Improvement stage exercises (Figure 5C) included i) T's and W's, ii) Quadruped Scapular Flexion, iii) One Arm Pushup Hold, iv) Pushups, v) Single Leg Romanian Deadlift, vi) Single Leg Bridges, vii) Advanced Dead Bugs, and viii) No Moneys w/ Chin Tuck.

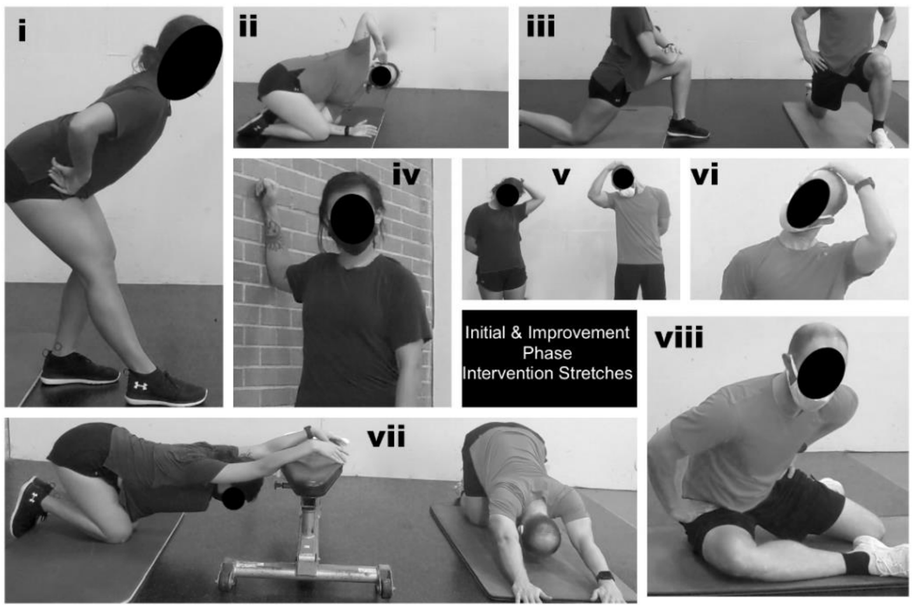

Figure 5A. Initial and improvement phase intervention stretches.

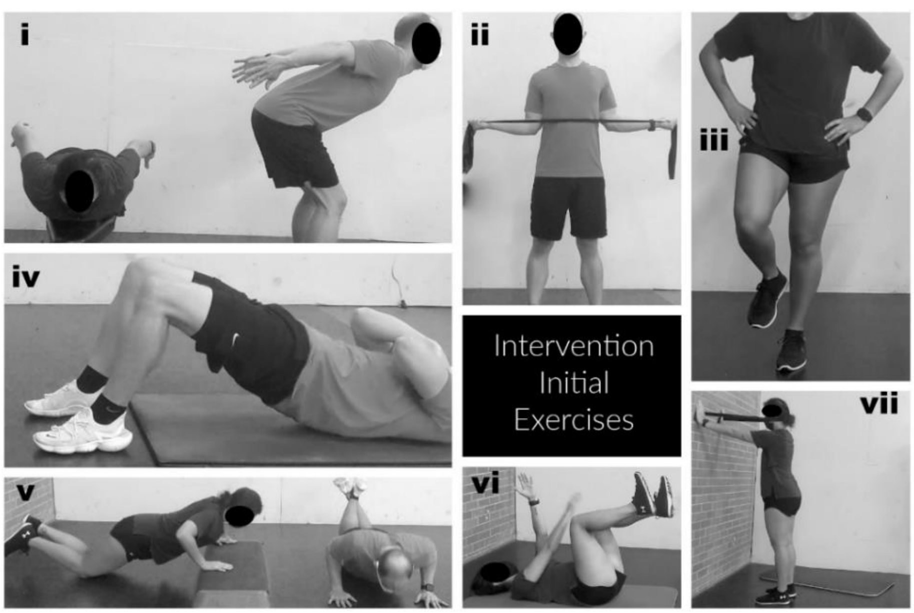

Figure 5B. Intervention initial exercises

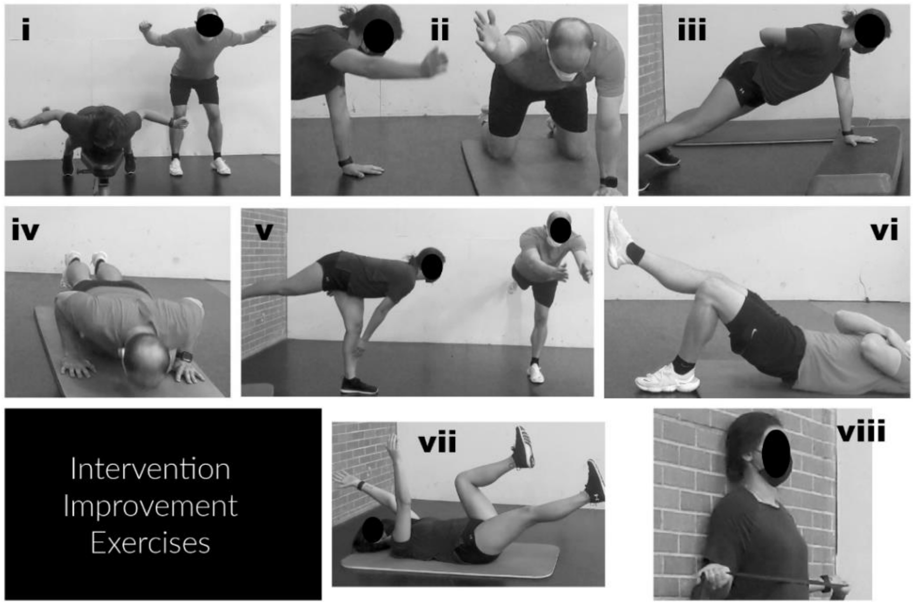

Figure 5C. Intervention improvement exercises

General exercise group exercises. The initial phase for the general exercise group consisted of the following stretches (Figure 6A) i) Chest, ii) Hamstring, iii) Hip Flexors, iv) Upper Trapezius, v) Tricep, vi) Cross Body, vii) Levator Scapulae, viii) Calf. The following strengthening exercises (Figure 6B) were used for the initial phase of general exercise: i) Calf Raises, ii) Pushups, iii) Tandem Balance, iv) Banded Rows, v) Plank, vi) Squats. The improvement phase again included stretches (Figure 5A) and exercises (Figure 6C) i) Single Leg Balance, i) Banded Rows with Tricep Extension, iii) Single Leg Calf Raises, iv) Lunges, v) Plank Variation, vi) Pushups.

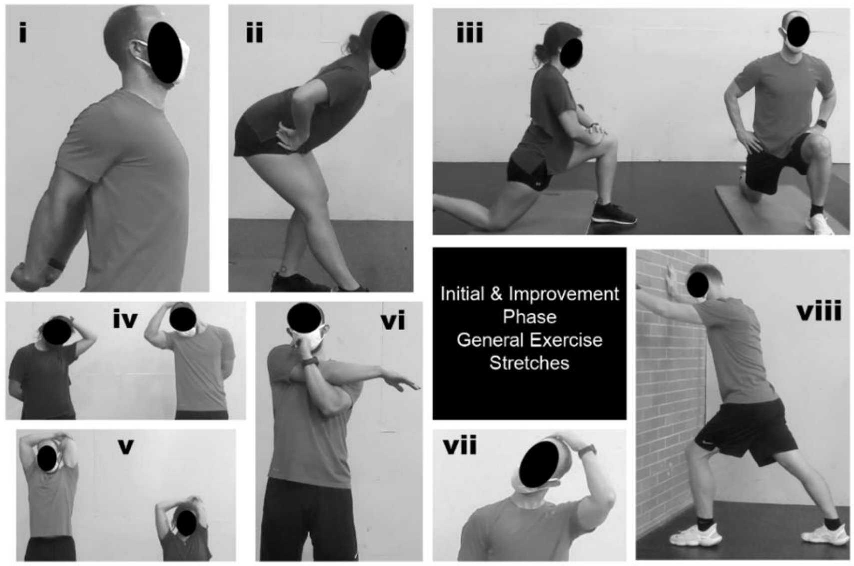

Figure 6A. Initial and improvement phase general exercise stretches

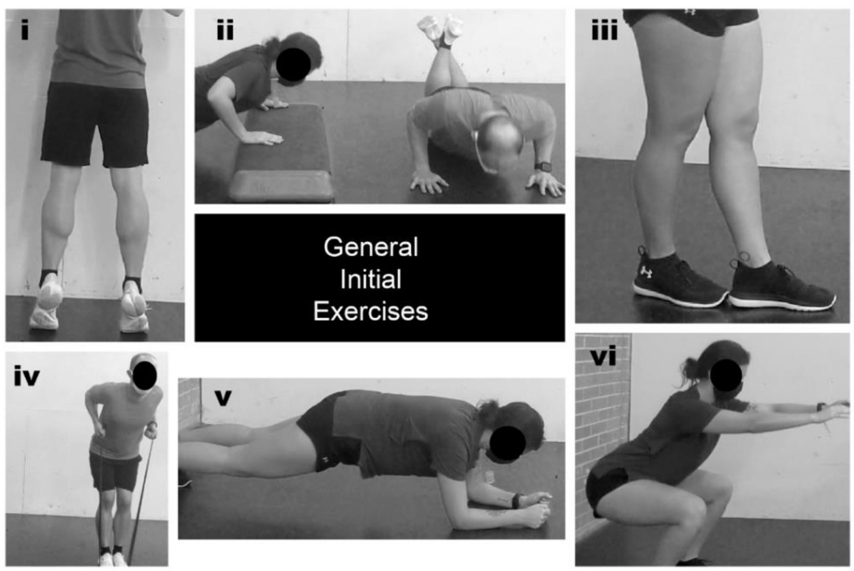

Figure 6B. General initial exercises

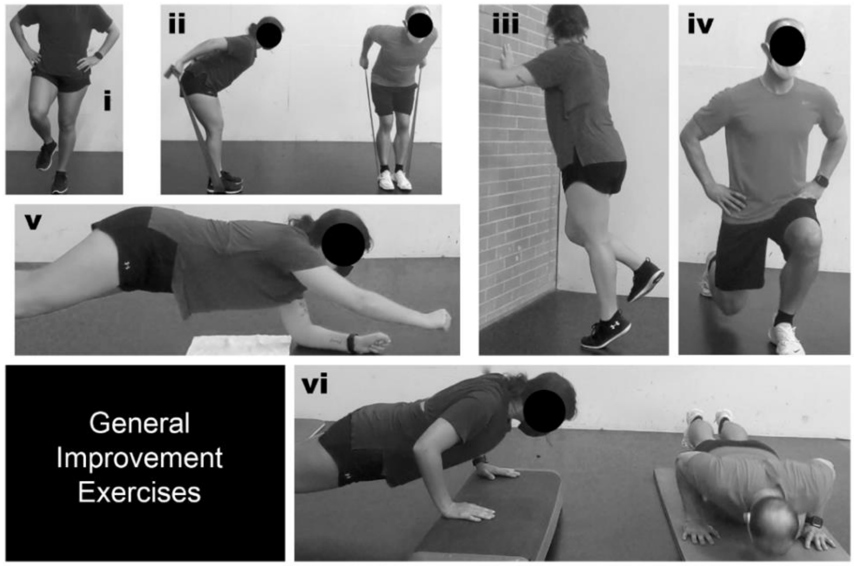

Figure 6C. General improvement exercises

Statistical Analysis

Separate individual 3 x 2 (treatment group x time) mixed model repeated measure ANOVAs were used to analyze all physical and psychological measures using SAS 9.4M7 (SAS Institute, Cary, North Carolina). Treatment group included Intervention Exercises, General Exercises, and Control and the Time factor included Pre and Post (8-wk) assessments. We used CVA angle as a covariant. To determine the best mixed model repeated measure design for each dependent variable, we used the intercept for each model and a variance-covariance structure. Alpha was set *apriori* at 0.05. Post-hoc Tukey tests were used to determine any interaction or main effects.

Results

Physical Measurements

CVA (º), DCFE (secs), SI (%) were measured at two times points for each of the treatment groups (Figure 7). There was an interaction effect (time*group) for CVA (º) ($F_{(2,37)}$=3.7, p=0.0001), but no interaction effect for DCFE (secs), or SI (%) (p=0.96 and p=0.89, respectively). Tukey post hoc test revealed that CVA angle for intervention pre (42.8 ± 1.5º) was less than CVA angle for intervention post (48.7 ± 1.6º) (p<0.0001).

There was no significant interaction effect for shoulder range of motion assessments including left and right internal and external rotation, flexion, and total range of motion (p>0.05); however, an interaction was seen for left shoulder flexion ($F_{(1,65.22)}$=5.18, p<0.05). Subjects demonstrated great variability in their pre- measurements, so even though we observed general improvement in shoulder ROM across all treatment groups, there was no statistical significance.

Patient-Rated Outcome Measures

Dispositional Positive Emotion Scale, Neck Disability Index, and General Anxiety Disorder

DPES (mean ± SE) also revealed no significant interaction (time*group) ($F_{(2,38)}$=1.70, p=0.20) (Figure 8). Means +/- standard error are presented in Figure 6B, from pre- to post- the intervention group improved 0.31, while the general exercise and control groups decreased 0.15 and 0.12 respectively (Figure 8 A).

NDI (mean ± SE) revealed no significant interaction (time*group) ($F_{(2,73)}$=0.11, p=0.89) (Figure 7). Small increases in disability were seen in both general (0.50) and control (0.22) groups, with a slight decrease for the intervention group (0.26) (Figure 8 B).

GAD-7 (mean ± SE) also revealed no significant interaction (time*group) ($F_{(2,38)}$=0.35, p=0.70) (Figure 8). Means ± standard error are presented in Figure 6B, from pre- to post- the intervention group decreased by 0.73, while the general exercise and control groups increased anxiety scores by 0.36 and 0.41 respectively (Figure 8 C).

PROMIS-29 Symptom Scales

There were no significant interaction (time*group) for anxiety ($F_{(2,34)}$=1.19, p=0.32), fatigue ($F_{(2,36)}$=0.05, p=0.95), sleep disturbance ($F_{(2,34)}$=1.10, p=0.34), or pain ($F_{(2,37)}$=0.84, p=0.44). For the intervention group, decreases in symptoms were seen for all measures: anxiety (4.88), fatigue (4.31), sleep disturbance (2.64), and pain (2.72). There were also very small decreases in the general exercise and control groups for anxiety (0.56 and 1.81 respectively) fatigue (4.26 and 5.37 respectively) (Figure 9 B, C, D, & F).

PROMIS-29 Function Scales

There were no significant interaction (time*group) for physical function ($F_{(2,37)}$=0.70, p=0.50), or satisfaction with social role ($F_{(2,35)}$=2.03, p=0.15). Improvements in function for these two scales were seen in both physical function (0.33), and satisfaction with social role (3.90) for the intervention groups., whereas the general exercise group and control group experienced declines (Figure 9 A & E).

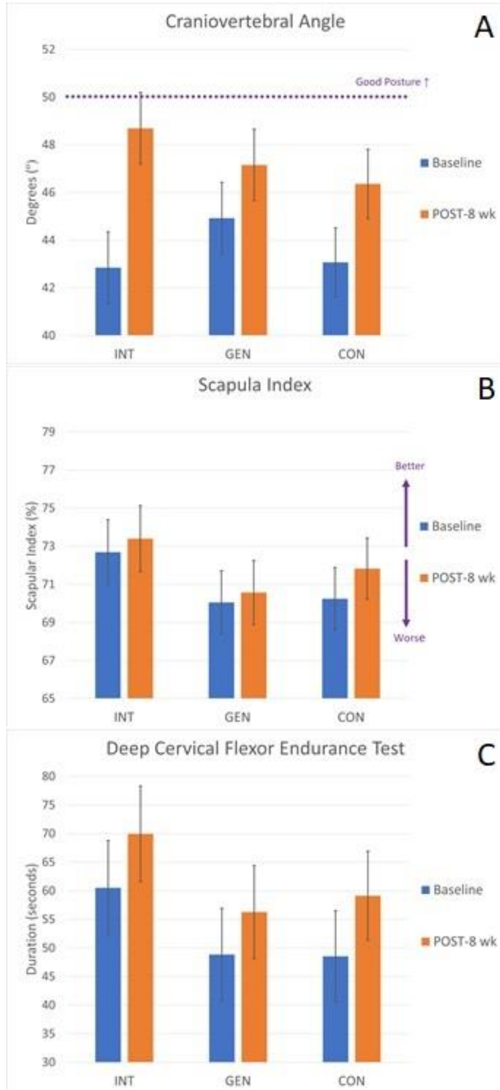

Figure 7. Physical measures of craniovertebral angle (a), scapular index (b) and deep cervical flexor endurance test (c).

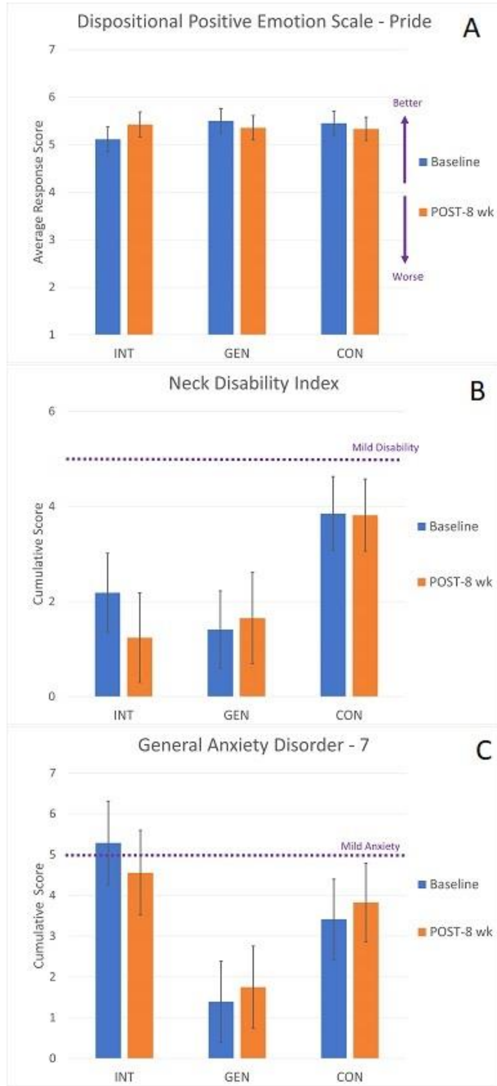

Figure 8. Patient-rated outcome scores for Neck Disability Index (NDI) (A), Dispositional Positive Emotion Scale – Pride (DPES)(B), and General Anxiety Disorder – 7 (GAD-7) (C)

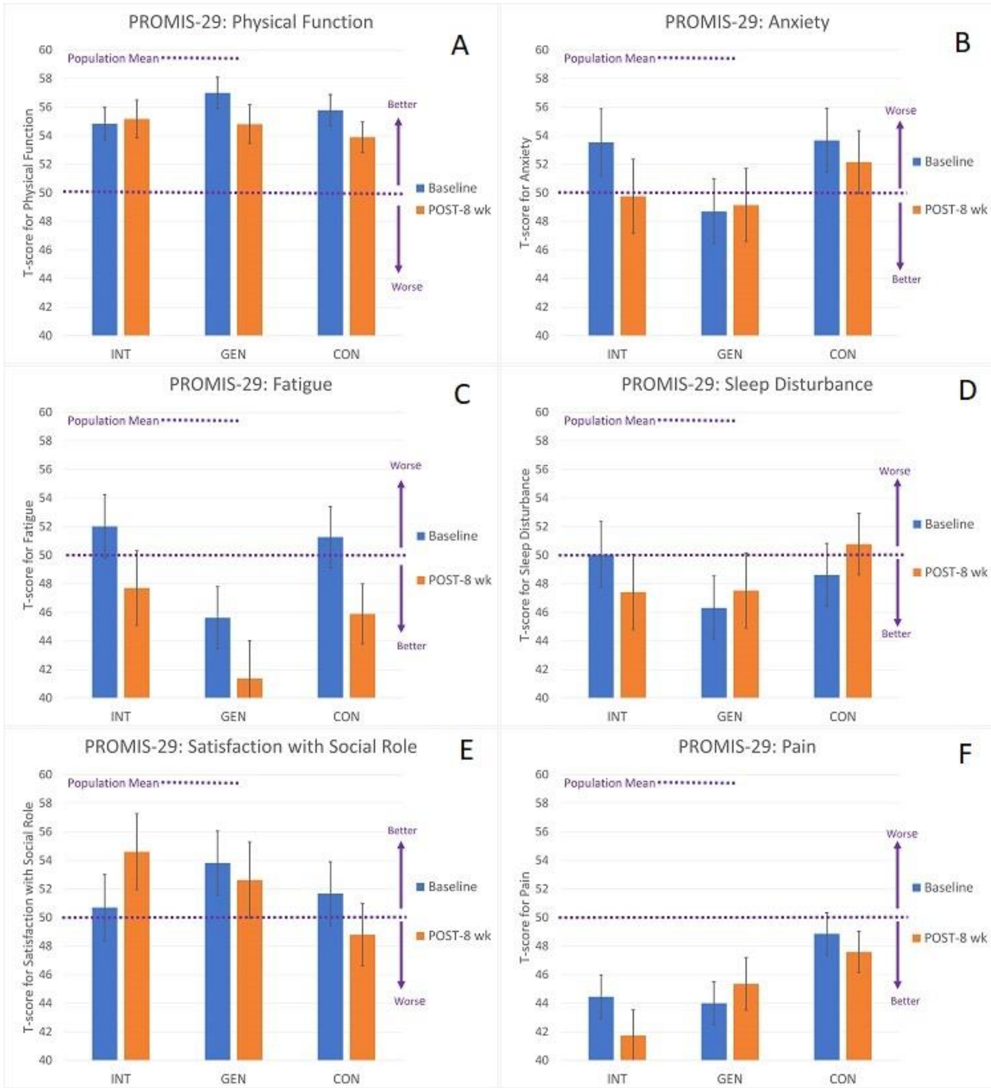

Figure 9. PROMIS-29 Scales for physical function (a), anxiety (b), fatigue (c), sleep disturbance (d), satisfaction with social role (e), and pain intensity (f).

Discussion

The purpose of this study was to investigate the effect of NI rehabilitation techniques on the treatment of FHP and psychological outcomes as recorded by a variety of patient-rated outcome scales. We hypothesized that if FHP improves through NI rehabilitation, there will also be an improvement in psychological patient-rated outcome scales as measured by components of the patient-rated outcome measurement information system (PROMIS-29), General Anxiety

Disorder – 7 (GAD-7), Dispositional Positive Emotion Scale – Pride (DPES), and Neck Disability Index (NDI). Overall, we did a significant improvement in the CVA angle for the intervention group and this change was not seen in the general exercise or the control groups. The mean change for the intervention group was approximately 6° of improvement or reduction in FHP. We did not demonstrate any significant changes for our other physical measures, or the different patient rated outcome scales. Participant's shoulder range of motion, DCFE, and SI showed no improvement or decline between any of the three exercise groups which could be attributed to the participants becoming more familiar with the testing procedures. However, it is important to note that observed changes for the patient rate outcomes within the intervention group were often in a direction of improvement, whereas the changes in for the general exercise and control group were either nil or in a direction of decline.

For example, the intervention group showed a decrease in NDI from pre (2.51 ± 0.80) to post (1.24 ± 0.94) (p=0.39), while the general exercise pre (0.92 ± 0.79) to post (1.65 ± 0.96) (p=0.71) and control group pre (3.69 ± 0.77) to post (3.81 ± 0.76) (p=0.91) showed small increases. The intervention group also exhibited mean values that constituted 'Mild Anxiety' at baseline (5.3 ± 0.97) according to the GAD-7 scoring system and this later became 'No Anxiety' at post measures (3.1 ± 1.1) following the completion of the integrated exercise intervention, while both the general exercise and control group (p=0.72) saw no changes in anxiety classification from baseline to post measures (Figure 8C). On the PROMIS-29, baseline anxiety and fatigue scores for the intervention group were higher than the population mean, but at post measurement the group scored below the population mean on both measures. (Figure 9 B & C).

Although the desire to ignore "insignificant" results is strong within academic literature, we believe that valuable clinical information may be lost if all p-values ≥ 0.05 are ignored, as evident by our GAD-7 classification change and score changes in many of our PROMIS subscales. Regarding the PROMIS-29 scale, changes of 2 and 6 T-score points have been shown to indicate meaningful changes according to Terwee et al. [67]. Despite the lack of significant results for any of the PROMIS-29 measures, beneficial changes of ≥ 2 T-score points can be seen in the intervention group for anxiety, fatigue, sleep disturbance, satisfaction with social role, and pain. If only p-values are assessed, then clinicians may very well miss out on clinically meaningful shifts in data in response to therapeutic intervention. Future studies with larger samples sizes and similar procedures may be able to achieve statistical significance and clinical meaningfulness. Future research would be also wise to include the Depression component of the PROMIS-29 scale.

Study Limitations

Exercises were distributed online via the QuestionPro system and were to be completed by participants in the comfort of their own home or personal space, as such, participants were not monitored for correct form, effort, or adherence. Future studies should perform these exercises under the supervision of a healthcare practitioner to better achieve adherence, which would also help with the mass attrition we faced over the course of the study. Additionally, our power analysis specified a minimum of 12 participants per group and we only just reached power.

Another key consideration is the population we used. Using college-aged students provides a unique concern when measuring anxiety outcomes due to the nature of a typical semester. Recruitment took place from the middle of a Fall semester to the start of Spring semester. The entirety of the study for a single participant would encompass mid-semester exams, final exams, and/or the start of semester where external stressors were kept to a minimum.

Conclusions

Overall, participants in the intervention group responded most to an exercise intervention designed to rehabilitate FHP when compared to general exercise and control. These intervention group participants improved their CVA measures using NI rehabilitation principles and saw consistent positive shifts in the patient-rated outcome measures over the course of the 9-week study. Therefore, we would encourage more exploration into the effects of a NI rehabilitation protocol to alleviate physical and psychological symptoms of FHP. In particular, exercises should be supervised by a healthcare practitioner and after completion of exercise protocol, a follow-up assessment should be completed to better understand the effects these postural improvements have on psychological outcome measures.

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CHAPTER 6

CONCLUSION

Forward head posture (FHP) and rounded shoulder posture (RSP), colloquially known as “text neck”,[1,2] impact a large proportion of the population and result from compensatory postural adaptations often associated with increases in screen time and a sedentary lifestyle. The increased use of computer and mobile phones has resulted in negative postural adaptations to our head and shoulders which impact anywhere from 61 to 85% of individuals.[3-7] Embodied cognition literature speaks to the notion that the mind and body function as an integrated unit, influencing one another and changing how we perceive and navigate our environment.[8-10] Together a pattern emerges between these musculoskeletal maladaptations, and the psychological ramifications that can result from sustaining these chronic postures. These negative postures have been linked to individuals displaying submissiveness,[11,12] less dominance,[13] sadness and being perceived as sad,[14-17] as well as influencing an individual’s gait,[18-20] muscle tonicity,[21-27] and cognitive functioning.[28-31] For example, Mehrabian [12] and Gifford [11] demonstrated that submission and subordination can be shown through aspects such as stooped and contractive postures, drawing the head into the shoulders, and retreating body orientations, whereas, dominant-ambitious individuals displayed a lack of forward head tilt. Physical rehabilitation practitioners are concerned with the physical functioning and musculoskeletal complications that arise from FHP and RSP, but clear links have been demonstrated how these stooped, kyphotic postures have a relationship with an individual’s psychological disposition. However, there is validation lacking on the reliability of RSP measures to assess a stooped posture, so measures of craniovertebral angle (CVA) provide the best measure for the classification of FHP which replicates the commonly cited negative postures that are referenced in psychological literature.

We believe that embodied cognition and the association of emotions with postural presentation is evident in the college aged population. Recent reports indicate that 20-36% of college-aged students are impacted my mental health issues,[32-35] with 27.4% having been diagnosed with anxiety and 21.7% with depression.[36] Study 1 reflected the prevalence of postural issues in a college-aged population with 94% and 96% of students identifying the desire to improve their sitting and standing postures, respectively. However, they were unaware of many of the common musculoskeletal rehabilitation techniques available to correct their posture. Based on these results, it was unsurprising to see 35% of individuals that considered themselves as healthy were classified as having Mild or Moderate neck disability as measured by the Neck Disability Index (NDI). Therefore, educating college-aged populations on good postural habits, safe ergonomic workstation set-ups, self-rehabilitation methods, while encouraging exercise participation could potentially offset some of the functional and psychological limitations prevalent in this population.

Neuromuscular integration (NI) rehabilitation principles focus on implementing a wholistic, full body approach to exercise-based rehabilitation to optimize and individual's ability to stabilize joints and postures, react to proprioceptive changes, and to improve activation patterns.[37] As rehabilitation techniques in lower extremity rehabilitation continue to adopt NI principles,[38,39] rehabilitation using these techniques for upper body postural disorders are less prominent. Study 2 was a systematic review of the literature designed to investigate a variety of NI rehabilitation techniques for FHP and RSP. We retrieved 6 articles – 4 for FHP, and 2 for RSP, and it was shown that through the implementation of these techniques, FHP benefited from a NI approach and was not detrimental to rehabilitating RSP.[40] A large degree of heterogeneity amongst the research articles showed variations in patient population, rehabilitation techniques, use of manual therapy, length of training intervention, and variation with RSP measurement techniques. The CVA measure has been validated and was used consistently throughout the FHP studies, but the lack of congruence amongst researchers as to the best measure for RSP could explain the lack of findings amongst the RSP studies. Although research is limited in this field, these results demonstrate that more research should be done to better establish the efficacy of these principles for upper body postural rehabilitation with the goal of improving proprioceptive ability – similar to the primary goal of NI principles in lower extremity rehabilitation.

In order to establish the need for exercise rehabilitation in a college age population, Study 3 investigated the psychological differences between individuals with bad posture and good posture as measured by FHP. A total of 121 college participants aged 18-26 were recruited and asked to fill out a variety of patient-rated outcome forms, perform physical measures, and have their posture measured using both CVA and SI. With SI not being a reliable metric, CVA was used to designate individuals as having either bad posture or good posture, and a cutoff of 50° was used whereby individuals greater than 50° qualified as having good posture. This cutoff was chosen based on previous literature.[41-43] All individuals were free of acute or chronic musculoskeletal injury, surgery to the upper body, and excluded if currently taking any prescription medication for anxiety and/or depression. Our findings showed that individuals with bad posture had higher levels of neck disability as measured by the NDI and were more anxious, more fatigued. They also had greater sleep disturbance and were less satisfied with their social role when compared to those with good posture as measured by the PROMIS-29 scale. In addition to statistical significance being found between these two groups, large Cohen's *d* effect sizes were also seen in these measures, ranging from 0.37 to 0.60 which would qualify as small to medium in magnitude. These results in a healthy population demonstrate that there are differences in psychological outcomes between individuals with bad and good posture. Providing the foundation for further research into the relationship between posture, rehabilitation, and psychology.

Because we found that posture and psychology were linked in a sample of healthy, college-aged individuals, we developed an investigation to see if rehabilitating an individual's bad posture could result in an improvement in psychological outcomes. To achieve this, Study 4 placed individuals with a CVA of ≤50° (bad posture) into one of three randomly assigned exercise groups and performed pre- and post- measurements on a variety of both physical and psychological outcome measures. We used an online exercise delivery and a minimal amount of equipment where one group performed a NI rehabilitation approach, another performed general exercises that would neither help nor exacerbate their current posture, and a final group did not perform any exercise intervention. Results showed that individuals who did improve their FHP as measured by CVA tended to have improved psychological outcomes, but no statistical significance was achieved. However, if only p-values are assessed, then clinicians may very well miss out on clinically meaningful shifts in data in response to therapeutic interventions. For the PROMIS-29 scales, the NI exercise group achieved minimal clinically important changes (MCID) which has been shown to be as small as 2 points. For example, the intervention group improved anxiety by 4.88 points, fatigue by 4.31points, sleep disturbance by 2.64 points, and pain by 2.72 points. It is our belief that a higher-powered study would further reveal these statistical trends and translate them into statistically significant results. Therefore, these results provide promising insight in future studies, particularly for participant populations that are symptomatic or diagnosed with any of those symptoms.

Overall, this topic shed light on multiple facets of posture and its relationship to psychological state. College-aged individuals demonstrated the ability to self-report deficiencies in their posture and have a desire to improve their posture with a high degree of congruence. Whole-body NI techniques have proven beneficial for rehabilitating FHP, and more research needs to be done using such methodologies. There are significant psychological differences between individuals with bad posture and those with good posture, with bad posture individuals displaying less desirable symptoms and more negative outcomes. And finally, rehabilitating FHP has demonstrated a tendency to positively shift some of these negative outcomes, but more evidence is needed.

Future research to delve deeper into the psychological ramifications of FHP rehabilitation would be wise to further investigate these findings using more strict and structured exercise programming that would be monitored by a health care practitioner. Expanding the participant population to encompass a variety of age groups and demographics would also provide insight into the role of posture on psychology separate to a college-aged setting.

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APPENDIX 1

STRETCHES AND EXERCISES FOR INTERVENTION GROUP

Appendix 1A. Stretches for Intervention Group

Initial Stage		
Stretch	**Repetitions**	**Description**
Piriformis	2 sets of 10 repetitions with 15second hold on the 10th repetition on each side	Sitting on the floor, place one leg at 90 degrees behind you, and the other at 90 degrees in front of you. Pull yourself down towards the floor as if to bring your sternum towards the front knee. Then push yourself back up to the starting position, focus on pushing through that front knee
Hip Flexors	2 sets of 10 repetitions with 15second hold on the 10th repetition on each leg	In a half-kneeling position with one leg out in front contract your glute to feel a stretch in the front of the hip. Move in and out of this stretching sensation for 10 repetitions. Hold the 10th repetition for a 15 second stretch. Repeat on the other side
Hamstring	2 sets of 10 repetitions with 15second hold on the 10th repetition on each leg	While standing, place one foot in front of the other and then move them hip width apart. Keep the forward leg straight and a slight bend in the back leg, try to keep all the weight on the front leg with the back leg being used for balance. Sit backwards until you feel a stretch and return to the starting position.
Upper Trapezius	2 sets of 10 repetitions with 15second hold on the 10th repetition on each side	While sitting or standing place your left arm behind your back. Nod your head down so your chin comes to your chest. Bend your neck to the right, and rotate your head towards your right pant pocket until you feel a stretch in the left side of your neck/shoulder area. Apply over pressure with your right hand, and actively contract against the hand on each inhale while relaxing during the exhales. Ensure you maintain the position of your head/neck throughout these contractions.
Levator Scapulae	2 sets of 10 repetitions with 15second hold on the 10th repetition on each side	While sitting or standing place your left arm behind your back. Nod your head down so your chin comes to your chest. Bend your neck to the right, and rotate your head up towards the sky until you feel a stretch in the left side of your neck/shoulder area. Apply over pressure with your right hand, and actively contract against the hand on each inhale while relaxing during the exhales. Ensure you maintain the position of your head/neck throughout these contractions.

Stretch	Repetitions	Description
Pectoralis Major & Minor Wall Stretch with External Rotation	2 sets of 10 repetitions with 15second hold on the 10th repetition on each side	Stand next to a wall where you are able to rest your forearm on the wall at shoulder height. Your shoulder and elbow should be at approximately 90 degrees. With your forearm on the wall rotate your torso until you feel a stretch in your chest. Then externally rotate your shoulder so that your forearm lifts off the wall
Thoracic Extension	2 sets of 10 repetitions with 15second hold on the 10th repetition	In a kneeling position, straighten place your hands and place them on a surface higher than the floor (this can be a bed, chair, couch etc). Next, ensure your torso is parallel to the ground. Then push down through the elevated surface with the aim of getting your chest to the floor.
Thoracic Rotation	2 sets of 10 repetitions with 15second hold on the 10th repetition	While kneeling, get your torso as close to your thighs as possible with a space between your knees. In this space, slide one elbow between your knees so that the ribs on that same side are on your thighs. Place your other hand behind your head, and rotate your torso towards the ceiling while keeping your ribs attached to your thigh.

Improvement /Maintenance Stage		
Stretch	**Repetitions**	**Description**
Piriformis	2 sets of 10 repetitions with 15second hold on the 10th repetition on each side	Sitting on the floor, place one leg at 90 degrees behind you, and the other at 90 degrees in front of you. Pull yourself down towards the floor as if to bring your sternum towards the front knee. Then push yourself back up to the starting position, focus on pushing through that front knee
Hip Flexors – Deep Lunge	2 sets of 10 repetitions with 15second hold on the 10th repetition on each leg	Move into a deep lunge with your back toes and knee still on the floor. Place both hands on the inside of your front foot for support. Contract the back quadricep muscle which will cause your knee to lift off the floor

Stretch	Repetitions	Description
Hamstring	2 sets of 10 repetitions with 15second hold on the 10th repetition on each leg	While standing, place one foot in front of the other and then move them hip width apart. Keep the forward leg straight and a slight bend in the back leg, try to keep all the weight on the front leg with the back leg being used for balance. Sit backwards until you feel a stretch and return to the starting position.
Upper Trapezius	2 sets of 10 repetitions with 15second hold on the 10th repetition on each side	While sitting or standing place your left arm behind your back. Nod your head down so your chin comes to your chest. Bend your neck to the right, and rotate your head towards your right pant pocket until you feel a stretch in the left side of your neck/shoulder area. Apply over pressure with your right hand, and actively contract against the hand on each inhale while relaxing during the exhales. Ensure you maintain the position of your head/neck throughout these contractions.
Levator Scapulae	2 sets of 10 repetitions with 15second hold on the 10th repetition on each side	While sitting or standing place your left arm behind your back. Nod your head down so your chin comes to your chest. Bend your neck to the right, and rotate your head up towards the sky until you feel a stretch in the left side of your neck/shoulder area. Apply over pressure with your right hand, and actively contract against the hand on each inhale while relaxing during the exhales. Ensure you maintain the position of your head/neck throughout these contractions.
Pectoralis Major & Minor Wall Stretch with External Rotation	2 sets of 10 repetitions with 15second hold on the 10th repetition on each side	Stand next to a wall where you are able to rest your forearm on the wall at shoulder height. Your shoulder and elbow should be at approximately 90 degrees. With your forearm on the wall rotate your torso until you feel a stretch in your chest. Then externally rotate your shoulder so that your forearm lifts off the wall
Thoracic Extension	2 sets of 10 repetitions with 15second hold on the 10th repetition	In a kneeling position, straighten place your hands and place them on a surface higher than the floor (this can be a bed, chair, couch etc). Next, ensure your torso is parallel to the ground. Then push down through the elevated surface with the aim of getting your chest to the floor.

Stretch	Repetitions	Description
Thoracic Rotation	2 sets of 10 repetitions with 15second hold on the 10th repetition	While kneeling, get your torso as close to your thighs as possible with a space between your knees. In this space, slide one elbow between your knees so that the ribs on that same side are on your thighs. Place your other hand behind your head, and rotate your torso towards the ceiling while keeping your ribs attached to your thigh.

Appendix 1B. Exercise for Intervention Group

	Initial Stage	
Exercise	**Repetitions**	**Description**
I’s and T’s	12-20 repetitions of I's 12-20 repetitions of T's	I's: Either using a table or bent over, ensure your torso is parallel with the ground with arms loosely dangling to the floor. Extend your arms backwards with palms facing each other using the muscles around your shoulder blade. Hold for 1-2seconds at the top of the movement and lower back down T's: In the same starting position as above, rotate your arm so the thumbs point away from the body. Lift your arms up so that your arms and body form the letter 'T', thumbs should be pointing to the ceiling. Hold for 1-2seconds at the top of the movement and lower back down
No Moneys	2 sets of 12-20 repetitions	While standing upright, grasp the resistance band in your hands with palms facing up towards the ceiling Bend your elbows to 90 degrees. Your upper arm should be aligned with the sides of your body. Without allowing your elbows to leave the sides of your body, pull the band apart by directing your thumbs outwards
Single Leg Balance	30seconds on each leg	Start by standing upright and close to a wall or chair that you can grab. Lift one leg off the floor so you are balancing on one leg. (If you lose balance, quickly recover back to a single leg stance). *Close eyes for added difficulty.
Bridges	2 sets of 12-20 repetitions	While lying on your back, bend your knees to approximately 90 degrees with your feet still on the floor. Contract your glutes and raise your hips off the floor
Floor Pushups	2 sets of 12-20 repetitions	Lying face down on the floor, place your hands under your shoulders, and support yourself with your knees. Push through your hands to lift your upper body off the ground - aim to push the ground away from you If this is too difficult, start with your hands on a raised platform or on your knees

Exercise	Repetitions	Description
Dead Bugs	2 sets of 12-20 repetitions	Lie on your back with your arms extended in front of you. Bend your knees and raise your thighs so your feet are no longer on the floor. You should be at 90 degrees at both your hips and knees. While maintaining this position, touch one hand to the opposite knee (your knee should remain still) - this is one repetition.
Banded Chin Tucks	2 sets of 12-20 repetitions	While standing facing a wall at arms length distance away, place the middle of the resistance band at the base of your skull. Grasp the ends of the resistance band so that there is tension throughout the band While holding the band, place your hands on the wall. You should feel your head start to move forward with the tension of the band - resist this. Your body and head should be in a straight line if someone were to watch you side on.

Improvement/Maintenance Stage		
Exercise	**Repetitions**	**Description**
T's and W's	12-20 repetitions of T's 12-20 repetitions of W's	T's: Using a table or while bent over, rotate your arm so the thumbs point away from the body. Lift your arms up so that your arms and body form the letter 'T', thumbs should be pointing to the ceiling. Hold for 1-2 seconds at the top of the movement and lower back down W's: In the same position as above, bend your elbows to 90 degrees. Lift your arms to the side so that your arms form the letter 'W'. Hold for 1-2 seconds at the top of the movement and lower back down
Quadruped Scapular Flexion	12-20 repetitions with 15second hold on the last repetition for each arm	While on all 4's on the ground (hands and knees) - your hands should be under your shoulders, and knees under your hips. Raise one arm up in front and 45 degrees off center line, until your arm parallel with the ground. Repeat this for 12-20 repetitions with a 15second hold on the last repetition Repeat with the other arm

Exercise	Repetitions	Description
One Arm Pushup Holds	15 seconds with each Arm	Starting in the top position of a pushup while on your knees, place one hand in the centerline of your body with your elbow straight and remove the other hand from a weight bearing position. While keeping your elbow straight, push the ground away from you and hold for 15seconds. If this is too difficult, start with your hands on a raised platform such as a bed or table
Banded No Moneys with Chin Tucks	2 sets of 12-20 repetitions	While standing upright with your back against the wall, grasp the resistance band in your hands with palms facing up towards the ceiling. Tuck your chin in as if you were squeezing a tennis ball between your chin and chest. Then bend your elbows to 90 degrees - your upper arm should be aligned with the sides of your body Without allowing your elbows to leave the sides of your body, pull the band apart by directing your thumbs outwards.
Dead Bugs – Opposite Arm/Opposite Leg	12-20 repetitions with Right Arm/Left Leg extended to 45 degrees 12-20 repetitions with Left Arm/Right Leg extended to 45 degrees	Dead Bugs - Opposite Arm/Opposite Leg - Extend Leg to 45 degrees. Lie on your back with your arms extended in front of you. Bend your knees and raise your thighs so your feet are no longer on the floor. You should be at 90 degrees at both your hips and knees - this is your starting position. Simultaneously, reach back with your Right Arm and extend your Leg Leg until both are 45 degrees from their starting positions - this is one repetition.
Single Leg Bridges	12-20 repetitions with each leg	While lying on your back, bend your knees to approximately 90 degrees with your feet still on the floor. Extend one knee so that the lower leg and foot raise off the floor, while keeping the thighs parallel. Contract your glutes and raise your hips off the floor by pushing through the remaining weight bearing leg
Single Leg Romanian Deadlift	12-20 repetitions with each leg	Stand upright and balance on one leg. With the non-weight bearing leg, ensure that it maintains a straight line with the torso. While maintaining this straight line, bend forward towards the floor with both legs as straight as possible. When you feel yourself lose this straight line, return to the starting position - this is one repetition

APPENDIX 2

STRETCHES AND EXERCISES FOR GENERAL EXERCISE GROUP

Appendix 2A. Stretches for General Exercise Group

Initial Stage		
Stretch	**Repetitions**	**Description**
Calf Stretch	1 set of 30second hold on each side	Put your hands against a wall and stand with a staggered stance. Move your one foot backwards while keeping your heel on the floor until you feel a stretch. Hold this stretching sensation for 30 seconds. Switch sides and repeat.
Hip Flexors	1 set of 30second hold on each side	In a kneeling lunge stance with one knee on the floor. While keeping your torso upright, contract your glute until you feel a stretch in the front of your hip. Hold this stretching sensation for 30 seconds. Switch sides and repeat.
Hamstring	1 set of 30second hold on each side	Place on foot out in front while keep the knee extended. Bend the back knee to push your hips back while keeping the front leg straight to feel a stretch in the back of your upper leg. Hold this stretching sensation for 30 seconds. Switch sides and repeat
Upper Trapezius	1 set of 30second hold on each side	While sitting or standing place your left arm behind your back. Nod your head down so your chin comes to your chest. Bend your neck to the right, and rotate your head towards your right pant pocket until you feel a stretch in the left side of your neck/shoulder area. Apply over pressure with your right hand if needed. Hold this stretching sensation for 30 seconds. Switch sides and repeat
Levator Scapulae	1 set of 30second hold on each side	While sitting or standing place your left arm behind your back. Nod your head down so your chin comes to your chest. Bend your neck to the right, and rotate your head up towards the sky until you feel a stretch in the left side of your neck/shoulder area. Apply over pressure with your right hand if needed. Hold this stretching sensation for 30 seconds. Switch sides and repeat
Chest Stretch	1 set of 30second hold	While sitting or standing with an upright torso, clasp hands behind your body. Reaching backwards while pinching your shoulder blades together until you feel a stretch. To intensify the stretch, keep your hands clasped and raise towards the sky. Hold the stretching sensation for 30seconds

Stretch **Repetitions** **Description**

Shoulder Across Body Stretch	1 set of 30second hold on each side	While sitting or standing with an upright torso place your arm across the body at shoulder height. Using your other arm, pull the arm closer to your chest until a stretch is felt on the shoulder. Hold this stretching sensation for 30 seconds. Switch sides and repeat
Overhead Tricep Stretch	1 set of 30second hold on each side	While sitting or standing with an upright posture, bend your left elbow and raise it Overhead. Using your right hand, grab the outside of the elbow pulling it deeper into a stretch. Hold this stretching sensation for 30 seconds. Switch sides and repeat

Improvement/Maintenance Stage

Stretch	Repetitions	Description
Calf Stretch	1 set of 30second hold on each side	Put your hands against a wall and stand with a staggered stance. Move your one foot backwards while keeping your heel on the floor until you feel a stretch. Hold this stretching sensation for 30 seconds. Switch sides and repeat.
Hip Flexors	1 set of 30second hold on each side	In a kneeling lunge stance with one knee on the floor. While keeping your torso upright, contract your glute until you feel a stretch in the front of your hip. Hold this stretching sensation for 30 seconds. Switch sides and repeat.
Hamstring	1 set of 30second hold on each side	Place on foot out in front while keep the knee extended. Bend the back knee to push your hips back while keeping the front leg straight to feel a stretch in the back of your upper leg. Hold this stretching sensation for 30 seconds. Switch sides and repeat
Upper Trapezius	1 set of 30second hold on each side	While sitting or standing place your left arm behind your back. Nod your head down so your chin comes to your chest. Bend your neck to the right, and rotate your head towards your right pant pocket until you feel a stretch in the left side of your neck/shoulder area. Apply over pressure with your right hand if needed. Hold this stretching sensation for 30 seconds. Switch sides and repeat

Stretch	Repetitions	Description

Levator Scapulae	1 set of 30second hold on each side	While sitting or standing place your left arm behind your back. Nod your head down so your chin comes to your chest. Bend your neck to the right, and rotate your head up towards the sky until you feel a stretch in the left side of your neck/shoulder area. Apply over pressure with your right hand if needed. Hold this stretching sensation for 30 seconds. Switch sides and repeat
Chest Stretch	1 set of 30second hold	While sitting or standing with an upright torso, clasp hands behind your body. Reaching backwards while pinching your shoulder blades together until you feel a stretch. To intensify the stretch, keep your hands clasped and raise towards the sky. Hold the stretching sensation for 30seconds
Shoulder Across Body Stretch	1 set of 30second hold on each side	While sitting or standing with an upright torso place your arm across the body at shoulder height. Using your other arm, pull the arm closer to your chest until a stretch is felt on the shoulder. Hold this stretching sensation for 30 seconds. Switch sides and repeat
Overhead Tricep Stretch	1 set of 30second hold on each side	While sitting or standing with an upright posture, bend your left elbow and raise it Overhead. Using your right hand, grab the outside of the elbow pulling it deeper into a stretch. Hold this stretching sensation for 30 seconds. Switch sides and repeat

Appendix 2B. Exercises for General Exercise Group

Initial Stage		
Exercise	**Repetitions**	**Description**
Double Leg Calf Raises	2 sets of 12-20 repetitions on both legs	While standing upright in front of a wall, place your feet roughly shoulder-width apart. Using the wall to balance, raise up on your toes while keeping your knees straight. Pause at the top of the movement, and slowly lower back down
Squats	2 sets of 12-20 repetitions	Stand upright with feet approximately shoulder-width apart. Lower down as close to parallel as your body allows you to while keeping your torso upright. Once your reach parallel, rise back up to the start position Try to maintain good posture throughout
Pushups on Knees	2 sets of 12-20 repetitions	Begin lying face down on the floor with your hands underneath your shoulders. Distribute your weight evenly between your hands and knees and push through your hands to raise your upper body off the ground. Push yourself up until the elbows are fully extended, before slowly lowering yourself down. If this is too difficult, consider doing pushups on a raised surface such as a chair, platform, or wall
Plank	2 sets of 30second hold	While lying face down on the floor. Place your elbows directly under your shoulders. While supporting yourself on your forearms and your feet, lift your body off the ground. While maintaining normal breathing, hold your body in this position for 30 seconds.
Staggered Tandem Balance	1 set of 30second hold with each leg forward	While standing upright, place one foot directly in front of the other with your hands on your hips. Maintain this position by using your balance for 30 seconds. Repeat with the other leg forward
Banded Rows	2 sets of 12-20 repetitions	Using a resistance band, grasp the ends of the band and step on the middle of the band so there is tension on the band. Bend at the hips so that your torso is parallel with the ground, your arms should be straight down to the floor. While bending your elbows, pull the band until the upper arm is aligned with the torso

Improvement/Maintenance Stage		
Exercise	**Repetitions**	**Description**
Single Leg Calf Raises	1 sets of 12-20 repetitions on each leg	While standing upright in front of a wall, place your feet roughly shoulder-width apart. Using the wall to balance, raise up on your toes while keeping your knees straight. Pause at the top of the movement, and slowly lower back down.
Lunges	1 sets of 12-20 repetitions on each leg	Stand upright with feet approximately shoulder-width apart. Move one leg 1-2ft in front of the other leg and lower down until the knee touches the floor. Then push yourself up to the starting position.
Pushups on Knees > Progress to Feet if Possible	2 sets of 12-20 repetitions	Lying face down on the floor, place your hands under your shoulders, and support yourself with your knees. Push through your hands to lift your upper body off the ground. If this is too difficult, start with your hands on a raised platform. If this is too easy, aim to do the pushup using your feet for support instead of your knees
Plank Variations	2 sets of 30second hold	Get face down on the floor by supporting yourself with your forearms on a towel or mat. You should be supporting yourself on your forearms and your feet, with your body lifted. While maintaining normal breathing, hold your body in this position for 30 seconds. For added difficulty try the following variations: 1) Alternate arm raises 2) Alternate leg raises 3) Opposite arm, opposite leg raises
Single Leg Balance	1 set of 30second on each leg forward	Stand on one leg, with the other leg bent slightly and your hands on your hips. While keeping your knee straight and torso upright, aim to hold this position for 30seconds without losing balance. Stand next to a wall or chair for help with balance if needed. Repeat on the other leg

Exercise	Repetitions	Description
Banded Rows w/ Tricep Extension	2 sets of 12-20 repetitions	Using a resistance band, grasp the ends of the band and step on the middle of the band so there is tension on the band. Bend at the hips so that your torso is parallel with the ground, your arms should be straight down to the floor. While bending your elbows, pull the band until the upper arm is aligned with the torso, then extend your elbows until your arm is straight back behind you.