The effects of the Alexander Technique training on neck and shoulder biomechanics and posture in healthy people

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For Lizzy and Xavier
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**ABSTRACT**

The aim of this Master’s study was to quantify the effects of an eight week, 20-lesson Alexander Technique (AT) training program on neck/shoulder postural alignment, range of motion and muscle activity in healthy people during tasks that targeted the head-neck/shoulder relationship. Post AT training laboratory assessments revealed a decrease in upper thoracic kyphosis in a static seated posture task and in a computer typing task. There was an increase in serratus anterior muscle activity amplitude at 120 degrees of a weighted shoulder flexion task and an increase in shoulder flexion range of motion. Since posture appears to be a risk factor for musculoskeletal disorders, and reduced shoulder range of motion as well as maintaining work-specific postures with static muscle activation have been associated with chronic neck and shoulder disorders, the AT may have some clinical benefit as a rehabilitation, and also as a preventative, approach for neck/shoulder disorders.
RÉSUMÉ

Le but de ce projet de maîtrise était de mesurer les effets d’un programme de huit semaines, 20 leçons de technique Alexander (AT) sur l'alignement postural cou-épaule, l’amplitude de mouvement et l'activité musculaire de personnes en bonne santé pendant des tâches qui visaient la relation tête-cou-épaule. Les évaluations de laboratoire post-entraînement ont indiqué une diminution de la cyphose thoracique durant des tâches statiques d’assise et d’entrée de texte à l'ordinateur. Il y avait une augmentation d'amplitude d'activité du muscle serratus antérieur à 120 degrés d'une tâche de flexion d'épaule avec charge et d'amplitude de flexion d'épaule. Puisque la posture semble être un facteur de risque pour des troubles musculo-squelettiques et que les déficits d’amplitude ainsi que le maintien de postures de travail spécifiques avec l'activation musculaire sont associés aux troubles chroniques de cou-épaule, l’AT pourrait présenter un avantage clinique comme approche de réadaptation et de prévention des troubles cou-épaule.
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INTRODUCTION

The complexity and synergistic qualities of the human body often go unnoticed or are underappreciated on a daily basis until, unfortunately, one or more of the ‘services’ it provides either malfunctions or is compromised. It is usually only then that we begin to analyze and appreciate the marvellous yet delicate biomechanical infrastructure of the human body. The shoulder joint and the neck are prime examples, as they embody cons of biological design and play significant roles in the effective completion of our day to day activities and job-related duties. Despite the shoulder joint and neck’s versatility and built-in ‘safety features’, they are often subject to the potentially destructive forces of repetitive motion, gravity, neglect, ageing and injury. Moreover, technological advancement in society has influenced a change in lifestyle in the way one works and pursues leisure activities. The workplace is now typically characterized by repetitive motions and the need to maintain work-specific postures with static muscle activity patterns, both being associated with chronic neck and shoulder disorders in the literature (McLean, 2005). Recently, research has taken an in-depth look at the biomechanics of the neck and shoulder joints to understand the roles of muscles in movement and stability of the neck and shoulder joint (Borstad and Ludewig, 2002; Dayanidhi, Orlin, Kozin, Duff, and Karduna, 2005; Klopcar and Lenarcic, 2006; Lin et al., 2005; Szeto, Straker, and O'Sullivan, 2005a; Vermeulen et al., 2002; Wang, McClure, Pratt, and Nobilini, 1999). The shoulder girdle involves the articulation of the clavicle, proximal end of the humerus and the scapula. The very nature of these articulations affords the glenohumeral joint the greatest range of motion of all joints in the body and, consequently, enables the human population to maximize the use of the arms and hands. To control this high structural mobility within the shoulder joint, a coordinated effort of nearly 30 muscles and of a strong ligamentous system is required. Closely located superior to the shoulder girdle are the neck and head that also afford a variety of movements including rotation, lateral flexion, extension, hyperextension, flexion, protraction, and retraction. The neck is often engaged concurrently with the
shoulder girdle in movements that require synchronous motions of the scapulothoracic, acromioclavicular, glenohumeral, and sternoclavicular joints.

Neck and shoulder disorders are an increasingly common occurrence, and studies have suggested that the misalignment of the cervical and thoracic spine can be a cause of acute and chronic pain in the shoulder girdle (Kebaetse, McClure, and Pratt, 1999; Theodoridis and Ruston, 2002; Wang et al., 1999; Warner, Micheli, Arslanian, Kennedy, and Kennedy, 1992). In addition, injury and muscle imbalances can adversely affect the kinematics of the shoulder girdle (Dayanidhi et al., 2005; Endo, Yukata, and Yasui, 2004; Finley and Lee, 2003; Kebaetse et al., 1999; Wang et al., 1999). Arm elevation is often accompanied with movement, in part or in whole, of the vertebral column. However, dysfunctional scapular movement alters the relationship between the scapula and humerus during shoulder function (Michener, McClure, and Karduna, 2003). When this relationship is altered, coupled with a non-neutral vertebral posture, the shoulder’s range of motion is reduced (Bullock, Foster, and Wright, 2005). Shoulder impingement, bursitis, and upper and lower back pain are some of the common complaints associated with non-neutral postures and abnormal shoulder girdle kinematics and muscle activity. Various postures have been studied to examine their role in neck/shoulder biomechanics, with studies concluding that posture plays a significant role in neck/shoulder pain and dysfunction (Bullock et al., 2005; Finley and Lee, 2003; Gerr, Marcus, and Monteilh, 2004; Kendall, McCreary, Provance, Rodgers, and Romani, 2005; Szeto, Straker, and Raine, 2002). Rehabilitation approaches have attempted to correct abnormalities in a number of ways, including but not limited to, strengthening and stretching exercises, ultrasound therapy, movement therapy and increasing postural awareness, most often with mixed results. Lately, the health care setting has turned its eye towards the use of postural training as a method of either treating or preventing neck, back and shoulder issues among the population, yet finding reliable studies for the effectiveness of such interventions is rare.
A recent avenue of research has focused on an intervention called the Alexander Technique (AT). The AT was born into the performing arts culture but has recently gained a toehold in mainstream healthcare and has captured the eye of academic researchers interested in applying the technique to a variety of health issues. The AT uses the student–teacher paradigm to enable students to become more kinaesthetically aware of posture and to make changes to problematic habitual movement patterns (Jain, Janssen, and DeCelle, 2004). The student is taught to recognize the sources that trigger the tension response and inhibit the habitual negative movement pattern and replace it with a more efficient movement pattern with respect to timing, direction and reduced tension, and with emphasis on the head, neck and spine. The aim of AT is to help students increase their body awareness and in turn, utilize that information to follow a more efficient way of functioning. The AT involves training students in one-on-one sessions, with cues geared towards reducing abnormalities in curvatures of the spine, releasing tension, and improving freedom of movement, posture, balance, and coordination through the use of manual guidance and visual and proprioceptive cues. Sessions are comprised of exercising postures from semi supine positions, static seated posture, and more dynamic postures in walking, standing up and student specific activities (i.e. desk work, singing or guitar playing).

The AT profession is growing with approximately 2500 teachers worldwide offering their expertise to athletes, performance artists (Jain et al., 2004) and to the general public who seeks to improve their performance and reduce problematic habitual movement patterns. However, there are relatively few studies that have attempted to quantify the effects of the AT on health-related characteristics. Researchers have demonstrated that the AT has long-term benefits for a few cohorts of patients with low back pain and with Parkinson’s disease by reducing the amount of days in pain and increasing the number of activities that they can engage in (Little et al., 2008; Stallibrass, Sissons, and Chalmers, 2002). The AT also comprises of a long term educational element and has been shown to have a relatively high retention level in another cohort of patients with
Parkinson’s (Stallibrass, Frank, and Wentworth, 2005). It has also been shown in the literature that AT training has an influence on balance, vertebral alignment, pain and lateral trunk flexion symmetry in older women and in a case study of low back pain (Cacciatore, Horak, and Henry, 2005; Dennis, 1999). Despite the AT’s focus on the head/neck relationship and on posture, to this author’s knowledge, no studies have been carried out upon determining the effectiveness of an AT training intervention on neck/shoulder biomechanics, neither in healthy populations nor on those suffering from neck/shoulder pain. This would seem especially important given the high occurrence of work-related neck and shoulder pain (as much as 50% of the workforce) (McLean, 2005), that a fifth of all disability settlements payments for musculoskeletal disorders go to people with shoulder disorders (Michener, Walsworth, and Burnet, 2004) and that posture plays a significant role in neck/shoulder pain (Bullock et al., 2005; Finley and Lee, 2003; Gerr et al., 2004; Kendall et al., 2005; Szeto et al., 2002).

The main objective of this Master’s thesis was to test the effects of AT training on neck/shoulder biomechanics, posture, and muscle activity in healthy people. The experimental protocol seeks to elicit the biomechanical and muscular activity response via a number of tasks: maximal voluntary contractions, static seated posture, weighted shoulder flexion, computer typing, maximal reaching speed, neck range of motion, and shoulder range of motion. Since the AT focuses on the head-neck relationship, around which most AT sessions are designed, we hypothesized that an AT program would demonstrate significant effects on biomechanical characteristics associated with risk factors for neck/shoulder pain (i.e. posture, muscle activity patterns). The implications of this study, and subsequent supporting studies, could provide an enlightening perspective for the primary care community in its approach to chronic neck/shoulder pain care. Indeed, validation of AT as a significantly beneficial training approach could place the AT as a preventative and management option in this growing area of self health awareness, as well as placing the AT as a potential source for the reduction of the burden of neck/shoulder pain on the health care system.
LITERATURE REVIEW

Relationship between posture and the incidence of neck and shoulder disorders

Due to a rise in neck and upper limb disorders and subsequent medical and health insurance costs (Madeleine, Lundager, Voigt, and Arendt-Nielsen, 1999), there have been numerous studies researching the intricacies of neck/shoulder biomechanics in healthy and injured conditions (Borstad and Ludewig, 2002; Klopcar and Lenarcic, 2006; Lin et al., 2005). Current research suggests that there is a relationship between neck and shoulder disorders (Andersen et al., 2003; Szeto et al., 2005a; Szeto, Straker, and O'Sullivan, 2005b), and since cervical and thoracic alignment may influence the biomechanical function of the shoulder, a misalignment of the thoracic and cervical spine could be a cause of acute and chronic pain (Kebaetse et al., 1999; Theodoridis and Ruston, 2002; Wang et al., 1999; Warner et al., 1992). Thus, this literature review will present the current knowledge associated with both shoulder and upper spine biomechanics.

Utilization of the shoulder girdle occurs numerous times daily, and involves the coordinated effort of the muscles of the trunk, shoulder and neck. Although the prime movers, as the name suggests, are important in the completion of arm tasks, focus on the stabilizing muscles of the shoulder girdle and their impact (or lack thereof) on the respective joints and bones is imperative for understanding the relationship between posture and the incidence of neck/shoulder-related disorders. If one or a number of these muscles is impaired in any way, this could result in a change of motion of the three bones in the shoulder joint: the scapula, clavicle and humerus (Ebaugh, McClure, and Karduna, 2006; Szeto et al., 2005a, 2005b). In addition, common arm movements such as arm elevation are often executed in conjunction with the rotation, extension, flexion and lateral flexion of the thoracic and cervical spine. This process of combining motions of the spine and of the glenohumeral joint or more accurately, the scapulothoracic, acromioclavicular, glenohumeral, and sternoclavicular joints, into a smooth elevation of the arm is called scapulohumeral rhythm (often referred to as “humeroscapular rhythm”) (Brukner, Khan, and Anton, 2001; Ekstrom, Soderberg, and Donatelli, 2005).
Thus the shoulder girdle and thoracic spine form a synergetic relationship, highlighting the importance of synchronous movement at this body region during leisure and work activities.

Shoulder motion is also dependent upon the position of the upper back and scapula. In a neutrally aligned posture, the scapula rests flat against the upper thoracic wall, generally between the seventh and second thoracic vertebrae (Kendall et al., 2005). The scapula tips posteriorly and rotates upwardly during humeral elevation in healthy adults (Finley and Lee, 2003). Shoulder flexion range of motion (ROM) in an asymptomatic population, is typically from 0° to 180° and achieved through the combined movement of the shoulder girdle and shoulder joint. During flexion, the glenohumeral joint can accommodate 120° of movement, but the remaining 60° is complemented by the upward rotation and abduction of the scapula, thus facilitating the glenoid cavity to face anteriorly and the humerus to flex to 180°. In addition, after 90° of flexion, the humerus rotates medially. Inman, Saunders, and Abbott (1944) reported that between 30° and 170° of flexion, the glenohumeral joint provides 10° of movement and the scapula upward rotation 5° of movement for every 15° of motion. During the abduction phase to 90°, the glenohumeral joint and the shoulder girdle operate concurrently in a 2:1 ratio, with 60° of movement occurring in the glenohumeral joint and 30° occurring in the shoulder girdle involving scapula upward rotation (Ekstrom et al., 2005; Schünke, Schulte, Ross, Schumacher, and Lamperti, 2006). After 90° of abduction, the humerus rotates externally (Poppen and Walker, 1976). External rotation of the arm in the horizontal plane consists of the teres minor and infraspinatus muscles assisting the anterior part of the humerus to externally rotate and articulate with the glenoid fossa of the slightly adducted scapula (Hamilton, Luttgens, and Weimar, 2007). This well-coordinated action is likely controlled in a precise temporal sequence to produce full ROM in healthy subjects.

Four muscles, and their roles, are of particular interest when considering the integrity of the neck/shoulder musculoskeletal system: the serratus anterior (SA),
infraspinatus (INFRA), upper trapezius (UT) and the cervical erector spinae (CES). The SA muscle stabilizes the scapula and holds it near to the thoracic wall; it also elevates, protracts and upwardly rotates the scapula (Moore, Dalley, and Agur, 2006). The INFRA is one of the rotator cuff muscles and works both to stabilize the shoulder joint during adduction by drawing the humerus towards the glenoid fossa of the scapula, and to assist in external rotation of the humerus. The UT rotates, laterally flexes and extends the cervical spine, and upwardly rotates and elevates the scapula. The trapezius muscle is one of the most susceptible to the onset of chronic pain and one of the most responsive to mental stress — and therefore potentially plays a role in the deterioration of posture (Ashina, Jensen, and Bendtsen, 2003; McLean, 2005; Simons and Travell, 1999; Wærsted, Eken, and Westgaard, 1996; Waersted and Westgaard, 1996; Westad, Mork, and Westgaard, 2004). Finally, the CES extends, laterally flexes, and rotates the cervical spine. Alterations in the function of these four muscles have previously been implicated in neck/shoulder disorders (Borstad and Ludewig, 2002; Caneiro et al., 2009; Endo et al., 2004; Lin et al., 2005; Ludewig and Cook, 2000; Lukasiewicz, McClure, Michener, Pratt, and Sennett, 1999; Matias and Pascoal, 2006; Szeto et al., 2005a; Voight and Thomson, 2000).

The role of non-neutral posture and associated muscle dysfunction in declining health

The workplace has changed dramatically over the last three decades, particularly with the addition of computer workstations and the domination of seated work in our society. Moreover, there has been an increase in leisure time computer use and seated activity. In parallel, a new set of musculoskeletal disorders (MSDs) and work-related neck and upper limb disorders (WRNULD) has begun to emerge over the past couple of decades (Bergqvist, 1993; Bernard, Sauter, Fine, Petersen, and Hales, 1994; Kamwendo, Linton, and Moritz, 1991; Tittiranonda, Burastero, and Rempel, 1999). In examining the role of posture in the epidemiology of MSDs among computer users, Gerr et al. (2004) concluded that despite inconsistencies in the studies reviewed, posture appeared to be an independent risk factor for MSDs among this population. In addition, the workplace is often
characterized by repetitive motions and maintaining work-specific postures with static muscle activations that are significantly associated with chronic neck and shoulder disorders (McLean, 2005). Combined, neck and shoulder pain is estimated to be as high as 31% in office workers who use computers, and as high as 50% worldwide in the workplace (Edmondston et al., 2007; McLean, 2005). This prevalent condition represents a considerable stress on the health care system and economy. Indeed, shoulder pain affects 16% to 21% of the population with approximately one fifth of all disability settlements payments for musculoskeletal disorders (MSDs) going to people with shoulder disorders (Michener et al., 2004).

A predisposition to injury and chronic pain in the upper back and the glenohumeral joint is abnormal alignment of the spine in the thoracic region and of the scapula and shoulder (Kendall et al., 2005). Endo et al. (2004) noted that in the shoulder abducted position (at a maximum of approximately 90°), with increasing age in groups of asymptomatic participants (16 - 73 years), there were decreases in scapular rotation, upward rotation angles and posterior rotation angles, which the authors posited were due to increased thoracic kyphosis. A kyphosed posture, often referred to as “hump/hunchback” or “Dowager’s hump”, is defined by abnormally high posterior thoracic curvature (Moore et al., 2006). Measurements for thoracic kyphosis of a normal spine, taken between T2 and T10, are approximately 40° (Keller, Harrison, Colloca, Harrison, and Janik, 2003). Lordosis, sometimes referred to as “sway/hollow back”, is defined by the lumbar vertebral column curving anteriorly where the pelvis has rotated anteriorly, producing an abnormal concave curvature of the lumbar spine (Moore et al., 2006). Whereas lordosis is commonly found among healthy and injured groups, kyphosis has been more closely associated with neck/shoulder disorders due to the direct biomechanical connection between the shoulder and upper spine. Finley and Lee (2003) noted that during humeral elevation in healthy adults, there were decreases in lateral rotation of the scapula and posterior tipping as a result of increased thoracic kyphosis. Thus, inefficient upward rotation of the scapula during shoulder elevation can diminish overall scapulohumeral rhythm. As suggested in the literature, kyphosed posture limits the shoulder ROM whereas a
normally erect posture can significantly increase shoulder flexion ROM (Bullock et al., 2005). The tightness of the UT, latissimus dorsi, pectoralis major and minor, levator scapulae and subscapularis muscles tends to pull the shoulder forward and internally rotate the humerus. Moreover, weakened muscles such as the rhomboids, middle and lower trapezius, teres minor, INFRA and SA also contribute to this rounded shoulder posture (Manske, Reiman, and Stovak, 2004). Although not all studies agree on the relationship between the forward head posture and rounded shoulders, and increased thoracic kyphosis (Raine and Twomey, 1997), increased scapular protraction and elevation combined with upper cervical extension and lower cervical flexion – commonly referred to as forward head posture and rounded shoulders – is a posture often observed in office workers, and has been shown to be the very same posture that clinical patients exhibit when reporting neck/shoulder pain (Szeto et al., 2002). The mechanisms behind this adverse posture can be explained the following way: when the thoracic spine is vertical, the center of mass of the head is slightly anterior to the atlanto-occipital joint axis of rotation, which requires the neck extensors to initiate extensor torque in order to support the head in static equilibrium. An increase in neck flexion would further increase the head and neck moment arm about the same axis of rotation, requiring an increase in extensor torque to support the head in static equilibrium (Burgess-Limerick, Plooy, Fraser, and Ankrum, 1999). Further, it is suggested that an increase in neck flexion increases the compressive forces in the cervical spine (Yoo, Yi, and Kim, 2006), and it has been shown that neck flexion beyond 30° diminishes the time to fatigue (Burgess-Limerick et al., 1999). The combination of extension of the atlanto-occipital joint and flexion of the cervical vertebrae, which are elements of forward head posture, are hypothesized as reasons for discomfort, injury and headaches (Burgess-Limerick et al., 1999). The increased neck flexion of a forward head and slumped posture creates tension and increases muscle activity in the levator scapula, potentially adding to the anterior tilting of the scapula in a kyphosed posture (Bullock et al., 2005; Sommerich, Joines, Hermans, and Moon, 2000). The length-tension relationship of the shoulder girdle muscles has been posited to
be adversely affected by an exaggerated kyphosed posture, thus altering scapulohumeral rhythm (Bullock et al., 2005). In addition, the anterior translation in a kyphosed posture can increase the co-contraction of the trunk muscles and the compressive load in the thoraco-lumbar vertebral column (Greig, Bennell, Briggs, and Hodges, 2008; Keller et al., 2003).

Some studies have provided experimental evidence for the presence of altered spine biomechanics in patient populations. In a comparison of neck/shoulder postures in asymptomatic and symptomatic office workers, Szeto et al. (2002) noted that when participants in the study were working with a computer, all had approximately a 10% increase in forward head posture when compared with the participants’ relaxed posture. They therefore posit that neck pain could be attributed to compressive forces in the cervical spine observed concomitantly to the forward head posture adopted during computer work (Szeto et al., 2002). Studies suggest that muscle imbalances may have a significant effect in altering shoulder and scapular kinematics as well as changing postural alignment (Dayanidhi et al., 2005; Endo et al., 2004; Finley and Lee, 2003; Kebaetse et al., 1999; Wang et al., 1999). For example, in a prolonged slouched posture, the pectoral muscles are shortened while the posterior scapular stabilizers are lengthened. As a result, the resting scapular position may be shifted anteriorly, causing pain in the shoulder area (Kendall et al., 2005; Michener et al., 2003). The subsequent anterior tilting of the scapula has been implicated as one of the causes of shoulder impingement syndrome (SIS) (Hébert, Moffet, McFadyen, and Dionne, 2002). Indeed, scapular muscle imbalances have been posited as contributing to scapular dyskinesia, a term used to describe altered scapular position and movement in a number of studies (Cools et al., 2007; Kibler and Sciascia, 2009). Two of the rotator cuff muscles, INFRA and supraspinatus, experience increased loading, and are more influenced by hand load than the deltoid muscle during arm elevation; such that, if these muscles are not functioning properly, the shoulder becomes more susceptible to subacromial impingement syndrome (SAIS) (Brox, 2003). Weakness of the upper and lower trapezius and SA muscles, and/or poor neuromuscular control, adversely affects
scapular motion and can result in mechanical dysfunction, SAIS, and supraspinatus outlet stenosis (Lukasiewicz et al., 1999). McQuade, Dawson, and Smidt (1998) examined the effects of fatigue on scapulohumeral rhythm during arm elevation exercises in the scapular plane. As a result of fatigue in the SA, the scapulohumeral rhythm during the 60° to 150° phase of arm elevation was significantly decreased thereby increasing the motion of the scapula. It is within this same range of glenohumeral motion that the shoulder joint is susceptible to SAIS, thus highlighting the importance of proper scapulohumeral rhythm, scapular stability and glenohumeral kinematics (Michener et al., 2003). In a study examining electromyographic (EMG) signals of four muscles (CES, UT, lower trapezius, anterior deltoid) in asymptomatic and symptomatic groups during a seated typing task, Szeto et al. (2005a) came to the conclusion that an elevated activation of the UT and of the UT/CES amplitude ratio is a maladaptive pattern since the UT is not anatomically well-designed to act as a stabilizer of the cervical spine during a typing task. It would appear then that it is necessary to monitor and further examine the muscle activity of the CES, UT, INFRA and SA, given their relationship with posture and their roles in dynamic and static contexts.

Misaligned thoraco-lumbar posture associated with the seated posture has also been studied at length in association with occupational spinal disorders. Caneiro et al. (2009) studied three different thoraco-lumbar sitting postures: slumped, thoracic upright, and lumbo-pelvic upright. Slumped sitting was defined as relaxed thoraco-lumbar spine with a posterior rotation of the pelvis; thoracic upright sitting was defined as shoulder blades in a slightly retracted position and anterior rotation of the pelvis with an extended thoraco-lumbar spine; and lumbo pelvic upright sitting was defined as the relaxation of the thorax and an anterior rotation of the pelvis that allows for a neutral lordosis of the lumbar spine (Caneiro et al., 2009). Their results demonstrated that slumped sitting, compared with thoracic upright sitting, was found to consist of significantly greater head/neck flexion and CES muscle activity. In another study aimed at analysing the effects of different sitting postures on muscle activity in the neck/shoulder region while participants performed a soldering task, Schüldt, Ekholm, Harms-
Ringdahl, Arborelius, and Németh (1987) found that the “whole spine flexed” position, defined as flexed cervico-thoracic and lumbar spine, elicited the highest activity levels in the UT and the CES. Conversely, the lowest UT and CES activity levels were observed in the “thoraco spine slightly inclined backward” posture. However, there appears to be a lack of a precise biomechanical interpretation of the postures during this study. Nevertheless, altered thoraco-lumbar posture with a tendency towards kyphosis appears to be an indicator for high levels of UT and CES muscle activity during non-neutral posture.

In a comprehensive review of the literature concerning the health of the lumbar spine and seated posture, Pynt, Mackey, and Higgs (2008) outlined a number of adverse consequences of a kyphosed sitting posture on the lumbar spine, combining to decrease the stability of the lumbar spine. These include increases in intervertebral disc shear forces, anterior annulus load, posterior annulus tensile forces, loading of the posterior ligamentous system, hydrostatic pressure in the nucleus of the disk, loading of the posterior fibres of the intervertebral disc, and creep in posterior spinal structures (Pynt et al., 2008). In addition, the decrease in nutrition of the discs and multifidus reflex may lead to degeneration of lumbar disc and, eventually, pain (Pynt et al., 2008). Pynt et al. (2008) therefore concluded that continued kyphosed lumbar seated posture, compared with lordosed lumbar seated posture, is more harmful to the health of the lumbar spine. They also expressed concern regarding the design of leisure seating that potentially furthers the negative effects of kyphosed posture. Interestingly, Pynt et al. (2008) noted a study that suggested that the effects on muscles and ligaments from a kyphosed posture lasts much longer than the time that the posture is actually sustained (Solomonow, 2004).

Although the lumbar region isn’t directly associated with neck and shoulder biomechanics, it is clear that the role of non-neutral posture, kyphosed spine in particular, has dire consequences for the integrity of the vertebral column and subsequent health of the individual. When reviewing the number of studies examining posture, lower back and neck/shoulder biomechanics, the role of non-
neutral posture in declining health becomes more and more evident, furthering the need to seek out rehabilitation techniques and preventative measures.

**Neck/shoulder rehabilitation approaches**

A number of studies that have summarized the effects of various therapeutic interventions for neck/shoulder disorders have delivered mixed results. Green, Buchbinder, Glazier, and Forbes (1998) carried out a systematic review of interventions for shoulder pain; however, with little uniformity in either shoulder disorder distinction or reliable and valid outcome measures, results were inconclusive. More recently, Michener et al. (2004) searched the scientific literature in the Cochrane Central Register of Controlled Trials Register, MEDLINE and Cumulative Index to Nursing and Allied Health Literature (CINAHL), from 1966 through to October 2003, and reached the conclusion that ultrasound therapy was ineffective for treating people with subacromial impingement syndrome. However, joint mobilization, exercises to strengthen the scapular and rotator cuff muscles, and stretching of the shoulder girdle were shown to be purportedly capable of producing the desired effect in treating SAIS. A similar conclusion for ultrasound therapy was reached upon examination of the Medline and Embase literature for treatment of people with soft tissue shoulder disorders, determining it as ineffective (van der Heijden, van der Windt, and de Winter, 1997). However, despite the literature favoring physiotherapy methods of laser therapy and manipulation, van der Heijden et al. (1997) concluded that the validity of the trials reviewed was “unsatisfactory”. Similarly, a review of the acupuncture literature revealed conflicting results with regards to pain, shoulder ROM, and self-reported function (Michener et al., 2004). Nevertheless, whilst the general body of the research may hold contradictions, an examination of some of the individual studies proves informative in better understanding the effects of rehabilitation methods on neck/shoulder pain.

Some of the research carried out focused on various strengthening exercises. For example, Wang et al. (1999) conducted an experiment studying the effects of strengthening exercises on scapular elevators and retrakters, external rotators and
glenohumeral abductors, and of stretching exercises of the pectoral muscles on shoulder kinematics and resting posture in participants who were asymptomatic and who had forward shoulder posture. After six weeks of exercise, there were increases in strength in horizontal abduction and internal/external rotation as well as a decrease in flexion (kyphosis) in the thoracic spine. However, despite the suggestion that the exercises and stretching aided in scapular stabilization, the scapular position remained unchanged at rest and shoulder posture had not changed. Another study involved strengthening the rotator cuff, increasing the flexibility of the shoulder joint, and delivering postural training (McClure, Bialker, Neff, Williams, and Karduna, 2004) for people with shoulder impingement over a six week period. The exercise intervention consisted of shoulder internal and external rotation and shoulder extension using a yellow Thera-Band. Participants then progressed to a green (stiffer) Thera-Band and completed scapular retraction, shoulder flexion, shoulder abduction, and external rotation exercises with the addition of various stretches of the shoulder girdle and a chin tuck exercise for postural training. Participants were given basic instruction in ergonomics pertaining to movement of the body and adapting the surrounding environment. Results yielded improved ROM and muscle force as well as reduction in pain, yet did not illustrate any changes in 3-dimensional scapular kinematics. Moreover, the study had no control group thereby raising the possibility of a placebo effect, or with changes possibly due to a passage of time and the natural progression of shoulder impingement. Cools et al. (2007) hypothesized that a select group of trapezius-strengthening exercises could rehabilitate muscle imbalance based on UT/lower trapezius, UT/middle trapezius, or UT/SA muscle activity ratios. They discovered that certain exercises were suitable for intramuscular trapezius muscle balance rehabilitation; however, none of the exercises Cools et al. (2007) chose to study affected the UT/SA muscle activity ratio. This led the authors to conclude that clinicians ought to use an exercise that has low activation for the UT as this would tend to produce a lower UT/SA muscle ratio, especially since a decrease in control of the lower trapezius and the SA combined with excess muscle activation of the UT has been suggested
as a contributor to abnormal scapular motion. Hagberg, Harms-Ringdahl, Nisell, and Hjelm (2000) conducted a study comparing isometric shoulder strength training with isometric shoulder endurance training in female industrial workers with neck shoulder pain. This purportedly resulted in a small decrease in the rate of perceived exertion (according to the Borg rating (Borg, 1982)) of job activities after isometric shoulder strength training and a 5% to 15% improvement in an arm motion test that required participants to move their hand as fast as possible between the back of the head and the lumbar region ten times. In addition, isometric shoulder strength training significantly improved the left side shoulder abduction strength, yet no major differences were shown for other strength measures. Researchers didn’t use a control group in the study, claiming that the inclusion of a control group could invite the placebo effect which can give as much as a 30% difference in effect measures and thus leading to incorrect conclusions (Hagberg et al., 2000). Thus it would appear that even though strengthening exercises can indeed strengthen the targeted muscles, it does not necessarily always affect scapular displacement and, therefore, posture either. It would seem a more global approach is necessary to address postural and biomechanical issues.

Among the various intervention methods for shoulder and spine impairments, Pilates has gained popularity as a method to improve posture, stabilize joints, strengthen the core and improve vertical alignment of the spine (Lange, Unnithan, Larkam, and Latta, 2000; Latey, 2001, 2002). More recently, Emery, De Serres, McMillan, and Côté (2009) completed a study on the effects of 12 weeks of Pilates training on arm and trunk posture and movement and observed a decrease in thoracic kyphosis complemented with an increase in abdominal strength. In addition, during shoulder flexion, there was an increase in ipsilateral CES and contralateral rhomboid muscle activation, and a reduction in posterior and mediolateral scapular displacement, upper thoracic extension segment angle ROM and lumbar lateral flexion segment angle ROM. The resulting improved posture and core strength led authors to support the use of Pilates as a suitable preventative measure in neck shoulder disorders.
In addition to the role of posture, some studies examined the role of posture awareness on neck pain. Edmondston et al. (2007) investigated the habitual sitting posture, postural repositioning error and perception of good posture in symptomatic people. The variables that were taken into consideration for analysis of the habitual sitting posture, postural repositioning error and perception of good posture are head tilt, cervico-thoracic angle, shoulder protraction, and head protraction, yet the authors give no definition of what constitutes a “good” posture, and nor did they define it for their participants. The results of this study showed no difference in postural repositioning error and habitual sitting posture between the groups, but when blindfolded, participants were asked to move from a relaxed position into what the participant perceived to be a good posture and there was a significant difference observed between the symptomatic and asymptomatic groups in what individuals perceived to be “good” sitting posture. The pain group had greater head protraction and less head tilt. However, the differences were small, leading authors to suggest that while some of the symptomatic participants may have found it difficult to adopt a “good” sitting posture, this study demonstrated no significant difference in kinaesthetic capacity compared with matched asymptomatic participants. The suggestion then, was put forth to look at patterns of muscle activity, as opposed to kinaesthetic awareness, when addressing the aetiology of postural neck pain.

Conversely, in an effort to study the change in cervical and thoracic posture after two different neck exercise interventions (endurance-strength training for the cervical flexor muscles and cranio cervical flexor training) in participants with neck pain, Falla, Jull, Russell, Vincenzino and Hodges (2007) showed that both groups had an improved capacity to maintain neutral cervical posture during prolonged sitting, though showed no change in disability (NDI) or pain (NRS) between the intervention groups (Falla et al., 2007). Participants were seated in an upright posture that authors defined as a vertical pelvic position with the adoption of thoracic kyphosis and lumbar lordosis (Boyling, Grieve, and Jull, 2004), and had a plumb line placed behind them. Pre-test results indicated that there was a change in the cervical angle for the neck pain participants over the
duration of a solitaire computer game-playing task, while the control group did not demonstrate any change for the same outcome measure. In addition, both the neck pain group and the control group had significant progressive increases in thoracic angle whilst completing the computer game-playing task. Post-tests revealed that both intervention groups experienced a reduction in disability NDI and pain NRS; however, there were no differences between the intervention groups. Alternatively, compared with the endurance-strength training for the cervical flexor muscles group, the craniocervical flexor training group experienced a decline in the change of the cervical angle over the course of the task. Both intervention groups improved their ability to maintain the upright thoracic posture. Falla et al. (2007) suggest that poor proprioception in the neck pain group may be a factor in the reduced kinaesthetic awareness of the head position; however, all the posture results were obtained using photographic analysis, raising questions as to the precise anatomical alignment of the spine. It is unknown if results would be maintained over time without continued intervention.

The theory that kinaesthetic awareness influences posture in symptomatic and asymptomatic populations needs to be further studied, as results are equivocal; however, it does appear that endurance and strength training are important considerations when improving posture.

Another study, involving female workers with neck/shoulder complaints, pitted the Feldenkrais method against physiotherapy interventions. The Feldenkrais method concentrates on spatial and self awareness through movement. The Feldenkrais teacher attempts to facilitate spontaneous functional movement in a verbal and touch-guided session with no specific outcome sought after, and is often experienced in a playful manner (Jain et al., 2004). Feldenkrais does not address posture directly, and developmental movements are usually done in a quasi gravity-eliminated position, such as lying down, rolling or crawling (Jain et al., 2004). Lundblad, Elert, and Gerdle, (1999) concluded that the Feldenkrais method was more effective than physiotherapy based upon equivocal evidence: a neck/shoulder complaint questionnaire response.
In summary, studies show that forward head, rounded shoulder and kyphosed posture are detrimental to the function and structural integrity of the spine and shoulder girdle, thus limiting their overall efficacy. Studies designed to specifically target muscles for stretching and strengthening appear to provide some success yet were equivocal about the relationship that encompasses kinaesthetic postural awareness, neutral posture, neck/shoulder muscle activity and kinematics. Therefore, studies are needed to precisely quantify the effects of postural training methods on neck/shoulder and spine kinematics concurrently with muscle activity during static and dynamic activities.

**Effects of Alexander Technique based training**

The Alexander Technique (AT) has been practised for over 100 years, primarily by performing artists. Its creator, Frederic Matthias Alexander, was himself an actor who founded the Alexander Technique as a result of voice problems he experienced during recitation (Jain et al., 2004). F.M. Alexander theorized that one could reset and redirect body motion by modifying counterproductive motor patterns prior to accomplishing movements, with a focused emphasis on the head, neck and back relationship. The AT consists of the use of the student-teacher paradigm to enable students to become more kinaesthetically aware of their posture and muscle tone and to make changes to problematic habitual movement patterns (Jain et al., 2004). To implement these hypotheses, students are typically taught on a one-on-one basis and learn through visual and proprioceptive cues to maintain 1) neutral postural alignment, and 2) minimal resting muscle tone, in order to achieve proper positioning of the head, neck and spine as they perform simple, everyday activities (e.g. sit-stand, going up and down stairs). The approach of an AT teacher is thus to facilitate the development of skills such as self-talk and visualization, whereby an individual can be more aware of actions that could affect healthy patterns of posture and movement. In turn, it is hypothesized that with practice, clients can improve upon these patterns so as to avoid developing long-term injury and disability.
Surprisingly, considering the AT’s popularity within the performing arts community (Leibowitz and Connington, 1990) – including the addition of the AT training within the curriculum to high profile institutions of the performing arts (such as the Juilliard School) – relatively few studies can be found on the technique in the current research literature. Of those few, Austin and Ausubel (1992) researched the effects of AT on respiratory function in healthy adults, and significant changes were noted in the treatment group, including increases in peak expiratory flow, maximal voluntary exhalation, and maximal expiratory mouth pressure, with authors postulating that the results may have been due to an increase in thoracic muscle compliance, strength and coordination. Valentine, Fitzgerald, Gorton, Hudson, and Symonds (1995) conducted an experiment to observe the effects of the AT on music performance in low and high stress situations. After 25 lessons in AT, the experimental group purportedly had improved overall musical and technical quality, there were decreases in heart-rate variance and self-rated anxiety, and participants had a more positive attitude towards performance. Results of this study supported the strong anecdotal evidence that the AT is effective in improving some qualitative aspects of artistic performance, lending support to its wide use and popularity in the performing arts domain.

Subsequent research by Stallibrass et al. (2002) investigated the therapeutic effects of 24 lessons of the AT on people with Parkinson’s disease. Included in the research design was another group of participants, who were given massage therapy as an intervention, to act as a control for touch and personal attention. The AT group improved on the Self-Assessment Parkinson’s Disease Disability Scale (SPDDS) at best and worst times of the day, more so than the massage group. Further addressing the issue of using the AT as a physical self-help technique, Stallibrass et al. (2005) studied the retention level following an AT training program in 28 people with idiopathic Parkinson’s disease six months after the AT lessons had ended. Survey results showed that all participants said that they were still using skills learnt throughout the AT lessons, suggesting that the AT may be effective in creating long-term habits that favour healthier life habits in this
population, although no scores on the retention of functional status were reported at the time of follow-up.

In a randomised controlled study on the effectiveness of AT training in chronic low back pain, researchers included massage therapy, doctor-prescribed exercises, and behavioural counselling from a nurse as treatments for low back pain (Little et al., 2008). The outcomes (number of activities impaired by back pain, number of days in pain) were measured at baseline, three months, and one year following the corresponding intervention. Results indicated that six lessons of the AT plus prescribed exercises were shown to be nearly as effective (72%) as 24 lessons of only the AT. Results demonstrated a significant reduction in days with back pain, which was greatest in the group who had 24 lessons in the AT, suggesting that the AT may be effective in alleviating pain in one pathological population (sufferers of low back pain).

A more biomechanical approach to research on the AT was conducted by Dennis (1999) to determine the effects of the AT on functional reach (FR) – a clinical measure of balance – in women over the age of 65. After four weeks of eight 1-hour sessions twice a week of AT training, there was a significant improvement (32.2%) in FR performance in the experimental group. However, a decline in FR performance was noted one month following the intervention, leading the author to suggest that the AT would be more effective, and may have a higher retention level, with an increase in the number of lessons.

Finally, in a study investigating the motor control aspects related to AT training, Cacciatore et al. (2005) presented a case study regarding a 49 year-old woman with a 25-year history of chronic lumbosacral back pain, who had laterally asymmetric automatic postural responses to postural perturbations. An instructor certified by the American Society for the Alexander Technique gave the client 20 AT treatments. The client’s lateral trunk curvature was measured at quiet or normal stance and was quantified by using kinematic markers, in particular at the L3 spinal level where the curvature was greatest and was close to the client’s felt pain. Post AT treatment, the L3 lumbar curvature decreased from $6.8^\circ \pm 1.0^\circ$ to
1.6° ± 0.8°. Pre AT treatment, voluntary leftward lateral bends were performed; the client’s leftward lateral trunk flexion was greater than the rightward translations across spinal levels L3 by 10° ± 1.2°, at L1 by 6.9° ± 1.0°, and at T7 by 5.8° ± 1.1°. Post AT treatment illustrated an increase in lateral trunk flexion symmetry of rightward and leftward responses at the spinal levels L3, L1, T7, and T4. In addition, total lateral trunk flexion following perturbations increased in both directions from 13.7° ± 1.4° to 17.1° ± 1.8° for leftward translations and from 8.9° ± 2.3° to 18.7° ± 3.2° for rightward translations. Centre of pressure anterior displacement was also measured, and demonstrated a decrease from 4.5cm ± 1.5cm to - 0.2cm ± 2.2cm for leftward translations, and a decrease from 15.9cm ± 1.9cm to 4.8cm ± 2.1cm for rightward translations. During a one-legged stance test prior to the AT treatment, the client had a notably deficient ability to balance on the left leg and illustrated shear forces in the frontal plane and lateral deviations in the body position. Post AT treatment indicated a root mean square (RMS) shear for right-legged balance decreasing from 3.2N ± 0.7N to 2.1N ± 0.3N and a decrease of RMS shear from 12.3N ± 3.7N to 3.2N ± 0.5N for left-legged balance, suggesting an overall improvement in balance for both legs. Perhaps most importantly for the client, a reduction in pain was observed to the point that pain was limited to one to two days per month compared to daily before treatment. Taken together, these findings strongly suggest improved balance and symmetry after AT training in this one individual. Although only a case study, this was the first to use detailed biomechanical analyses to offer objective support to claims of the effectiveness of the AT in improving postural control in a back pain patient.

In conclusion, although some recent studies have investigated the effects of the AT on some aspects of posture, none have investigated the effect of the AT on neck/shoulder biomechanics. The AT emphasizes posture, vertebral vertical alignment, muscular activity, and efficient muscular coordination during dynamic tasks. Since a review of the literature implicates posture, scapular kinematics and muscle dysfunctions as risk factors for neck/shoulder dysfunctions, and considering the AT has a head, neck, and back relationship centered approach,
there is an evident need to quantify the effect of the AT on neck/shoulder biomechanics. This study is a first step in validating the effectiveness of AT among healthy subjects using a laboratory-based biomechanical assessment protocol including tasks that are relevant to daily and occupational activities. This study could then lead to others with patient groups, where studying the effects of the AT on neck/shoulder biomechanics may reveal significant results in the fields of prevention and rehabilitation.
The effects of the Alexander Technique training on neck and shoulder biomechanics and posture in healthy people.

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ABSTRACT

Background: Posture and muscle imbalances have been shown to adversely affect shoulder and spine kinematics and can be a cause of acute and chronic pain in the neck and shoulder. The Alexander Technique (AT) enables students to become more kinaesthetically aware of posture and to make changes to problematic habitual movement patterns. The objectives of this study were to determine the effects of 20 lessons of AT training on neck and shoulder biomechanics, posture and muscle activity in healthy people.

Methods: 20 asymptomatic participants (AT training group mean age = 30.9; 2 males, 8 females; control group mean age = 26.1; 3 males, 7 females) were assessed in the laboratory before and after an eight week AT training program. AT training consisted of 45 minute sessions three times a week for four weeks and then two times a week for four weeks. Assessment included neck, shoulder, scapula and trunk displacements and average positions as well as muscle activity amplitude of the cervical erector spinae, upper trapezius, infraspinatus and serratus anterior during three tasks: static seated posture, typing and shoulder flexion while holding a weight. Maximal reaching speed for a task at shoulder height and shoulder joint range of motion (ROM) in flexion, abduction and external rotation, as well as neck ROM in rotation and lateral flexion were also assessed.

Findings: Post AT training, there was a decrease in upper thoracic kyphosis in the static sitting (~5°) and typing (~6°) tasks. AT was also associated with an increase of 29.7% in serratus anterior muscle activity amplitude at 120° of the weighted shoulder flexion task and with an increase in shoulder flexion ROM of about 9°.

Interpretation: Results suggest that the AT training program was effective in improving upper thoracic posture, patterns of scapular stability and shoulder ROM. Since posture appears to be an independent risk factor for musculoskeletal disorders and that reduced shoulder range of motion as well as deficits in maintaining work-specific postures with static muscle activation are significantly
associated with chronic neck and shoulder disorders, the AT may have some clinical benefit as a rehabilitation approach for neck/shoulder disorders and also as a preventative, self awareness approach.
1. Introduction

The neck and shoulder joints are often subject to the potentially destructive forces of repetitive motion, gravity, neglect, ageing and injury. In addition, technological advancement in society has influenced a change in lifestyle in the way one works and pursues leisure activities. The workplace is often characterized by repetitive motions and maintaining work-specific postures with static muscle activation that have been previously associated with chronic neck and shoulder disorders (McLean, 2005; Szeto et al., 2002; Szeto et al., 2005a, 2005b). A rise in neck and upper limb disorders and subsequent medical and health insurance costs (Madeleine et al., 1999) have led to numerous studies aimed at describing in details the biomechanics of the neck/shoulder complex (Borstad and Ludewig, 2002; Klopcar and Lenarcic, 2006; Lin et al., 2005). Current research suggests that there is a relationship between neck disorders and shoulder disorders (Andersen et al., 2003; Szeto et al., 2005a, 2005b), and since cervical and thoracic alignment may influence the biomechanical function of the shoulder, it is thought that a misalignment of the thoracic and cervical spine could be a cause of acute and chronic neck/shoulder pain (Kebaetse et al., 1999; Theodoridis and Ruston, 2002; Wang et al., 1999; Warner et al., 1992).

Utilization of the shoulder girdle is an inherent part of functions that occur numerous times daily, and involves the coordinated effort of the muscles of the trunk, shoulder and neck. If one or a number of these muscles is impaired in any way, this could result in a change of motion of the three bones in the shoulder joint: the scapula, clavicle and humerus (Ebaugh et al., 2006; Szeto et al., 2005a, 2005b). In addition to the movements of the glenohumeral joint, shoulder flexion, or forward arm elevation is often executed in conjunction with the rotation, extension, flexion and lateral flexion of the thoracic and cervical spine. This process of combining movements of the scapulothoracic, acromioclavicular, glenohumeral, and sternoclavicular joints, into a smooth elevation of the arm is called scapulohumeral rhythm (Brukner et al., 2001; Ekstrom et al., 2005). A predisposition to injury and chronic pain in the upper back and the glenohumeral joint is abnormal thoracic alignment and misalignment of the scapula and
shoulder (Kendall et al., 2005). Thus, the shoulder girdle and thoracic spine form a synergetic relationship highlighting the importance of the roles played by shoulder muscles in producing synchronous movement during leisure and work activities.

Studies suggest that muscle imbalances may have a significant effect in altering shoulder and scapular kinematics as well as changing postural alignment (Dayanidhi et al., 2005; Endo et al., 2004; Finley and Lee, 2003; Kebaetse et al., 1999; Wang et al., 1999). It has been suggested that stiff and shortened pectoralis muscles, combined with weak posterior scapular stabilizing muscles, lead to a slouched posture, thereby moving the scapula anteriorly and potentially leading to pain in the shoulder area (Cools et al., 2007; Hébert et al., 2002; Kendall et al., 2005; Michener et al., 2003). Moreover, a lack of force in the rotator cuff muscles has been shown to increase the risk of subacromial impingement syndrome (SAIS) during arm elevation (Brox, 2003). Indeed, weakness of the upper and lower trapezius muscle and serratus anterior (SA), and/or poor neuromuscular control can adversely affect scapular motion and, subsequently, scapulohumeral rhythm (Lukasiewicz et al., 1999). It has also been shown that scapulohumeral rhythm during the 60° to 150° phase of arm elevation is significantly impaired by fatigue in the SA, also increasing the risk of SAIS (McQuade et al., 1998; Michener et al., 2003). Increased scapular protraction and elevation combined with upper cervical extension and lower cervical flexion – commonly referred to as forward head posture and rounded shoulders – is a posture often observed in computer users as well as in clinical patients reporting neck/shoulder pain (Szeto et al., 2002). Furthermore, elevated upper trapezius muscle activity and upper trapezius/cervical erector spinae amplitude ratio has been shown to be a maladaptive muscle activation pattern for stabilizing of the cervical spine during a monotonous typing task (Szeto et al., 2005a). In addition, thoracic kyphosis, an abnormal increase in thoracic curvature (Moore et al., 2006), has also been shown to decrease lateral rotation and posterior tipping of the scapula, thereby adversely affecting scapulohumeral rhythm and decreasing shoulder range of motion (ROM) (Bullock et al., 2005; Finley and Lee, 2003).
Another element of this adverse posture, forward head posture may increase compressive forces in the cervical spine (Yoo et al., 2006) as well as neck flexion torque. In turn, this flexion torque induces a reactive neck extensor torque and therefore, neck extensor muscle fatigue. All of these have been mentioned as risk factors for discomfort, injury and headaches (Burgess-Limerick et al., 1999). In addition, kyphosed posture has been suggested to increase co-contraction of the trunk muscles and induce compressive load in the thoraco-lumbar spine (Greig et al., 2008; Keller et al., 2003). Thus, training and rehabilitation approaches that can target these postures could have significant impact on musculoskeletal health.

The Alexander Technique (AT) aims at enabling students to become more kinaesthetically aware of their posture and to make changes to problematic habitual movement patterns (Jain et al., 2004). The AT involves training students through the use of manual guidance and visual and proprioceptive cues by way of exercises that focus on the head, neck and spine relationship. More generally, the hypotheses behind the AT approach is that it is possible to teach the student to be better aware of the sources that trigger the tension response and to help them inhibit the habitual negative motor patterns and replace them with more efficient patterns with respect to timing and direction (Leibowitz and Connington, 1990). Despite the AT’s popularity within the performing arts community (Leibowitz and Connington, 1990) – including the addition of AT training within the curriculum of high profile institutions of the performing arts such as the Juilliard School – the AT has only recently begun to receive attention outside of this community.

Relatively few studies in the current research literature have focused on quantifying the true effects of AT training. Initially, studies focused on music performance related skills, indicating significant increases in peak expiratory flow, maximal voluntary exhalation, and maximal expiratory mouth pressure in healthy adults (Austin and Ausubel, 1992), as well as improved overall musical and technical quality and decreases in heart-rate variance and self-rated anxiety in participants performing music in low and high stress situations (Valentine et al.,
The effectiveness of AT in managing pathological conditions was later studied in a population with Parkinson’s disease, with authors finding that AT was effective in improving scores on the Self-Assessment Parkinson’s Disease Disability Scale (SPDDS) at best and worst times of the day (Stalibrass et al., 2002). In addition, six lessons of the AT with prescribed exercises were shown to be nearly as effective (72%) as 24 lessons of only the AT, including a reduction in days with back pain (greatest in the group that had 24 lessons of AT) in a study involving chronic low back pain sufferers (Little et al., 2008). More biomechanically-themed studies have shown a 40.8% improvement in functional reach (FR) – a clinical measure of balance – in women over the age of 65 after eight session of the AT (Dennis, 1999). Improvements in balance, vertebral alignment, pain and lateral trunk flexion symmetry also have been observed in a single-case study of a patient with low-back pain (Cacciatore, Horak, and Henry, 2005). Although studies have investigated the effects of the AT on some aspects of posture, to the author’s knowledge, none have investigated the effect of the AT on neck/shoulder biomechanics.

A review of the literature implicates posture, scapular kinematics and muscle dysfunctions as risk factors for neck/shoulder disorders (Kebaetse et al., 1999; Theodoridis and Ruston, 2002; Wang et al., 1999; Jon J. P. Warner et al., 1992), and considering that the AT focuses on the head, neck, and back relationship, around which interventions are designed, there is an evident need to quantify the effect of the AT on neck/shoulder biomechanics. In turn, this could provide an enlightening perspective for the primary care community in its approach to chronic neck/shoulder pain care. Thus, the main objective of this research was to measure the effects of a 20-session AT training program on neck/shoulder biomechanics, posture, and muscle activity in healthy people. For this, we designed an experimental protocol comprising of a number of tasks that closely implicate the head-neck/shoulder relationship. We hypothesized that the AT training program would be effective in improving head, neck and shoulder girdle posture and motion characteristics within a healthy population.
2. Methods

2.1. Subjects and Study Design

20 asymptomatic participants (10 for the AT training group, 10 for the control group) were recruited through advertisements and personal contacts to participate in a repeated measures study design. Participants were excluded from the experiment if they had been diagnosed by a medical doctor with a back, shoulder or neck musculoskeletal disorder in the last 6 months or if they had received prior Alexander Technique (AT) training. All participants were instructed not to change their usual physical activity habits for the duration of the study. The AT training group (mean age = 30.9; 2 males, 8 females) performed the experimental protocol before and after completing eight weeks of AT training. The control group (mean age = 26.1; 3 males, 7 females), matched to the experimental group on the bases of age, gender and hand dominance, performed the experimental protocol twice with eight weeks in between and received no AT training during that time. All participants recorded their physical activities and activity levels in a journal, signed consent forms obtained by the institutional ethics committee and were tested at the research facility in the Jewish Rehabilitation Hospital in Laval, Quebec.

2.2. Alexander Technique Training

The AT training program was administered by two AT practitioners certified by The Society of Teachers of the Alexander Technique (instructor 1) and Canadian Society of Teachers of the Alexander Technique (instructor 2). The training consisted of 45-minute sessions three times a week for four weeks and then two times a week for four weeks for a total of 20 AT sessions over eight weeks, all conducted in the instructors’ AT studios. A daily home program was added during the eight weeks.

The AT is a self help technique which is geared towards learning and maintaining better body use and functioning. Through verbal cues and manual guidance, the participant is taught how to better control the head, neck, and back...
relationship in the context of activities such as: active rest in supine position (table work), sitting and standing (Fig. 1a) (chair work), simple dynamic movements (lifting an arm, turning the head), and progressing to more complex movements (walking, climbing stairs, singing or playing an instrument, working at the computer). In the process the participant is taught how to recognize and inhibit their reactive and habitual motor patterns, such as unnecessary muscle tension, and learn how to make different (non-habitual) choices which improve posture and function.

A typical session at the beginning of the program included creating awareness of the length of the spine and tension in the supporting musculature in the supine position. Straightening the legs in the supine position and discussion of psycho-social triggers for tension followed. Exercises focusing on breathing and changes in posture while doing so were also performed. Learning to recognize and inhibit detrimental postural reactions to perceived stresses ensued. A typical session at mid-training included static sitting and supine postural exercises progressing from simple dynamic movements of lifting the arms and turning the head to more dynamic movements such as sitting down, standing up (Fig. 1b), walking, reaching for objects and working on the subsequent movement patterns and postures. Inhibition of unnecessary muscle tension and a more naturally flowing form of movement was emphasized. The relationship of the head, neck and back had been stressed throughout the sessions but became progressively integrated outside of the class during daily activities. By the end of the eight weeks of training, students had engaged in task-specific activities such as running, singing and playing a musical instrument while applying the lessons of the AT to those activities to create an efficiency and ease of movement and adjusting movement patterns according to sensory and cognitive input. Throughout each training session, proprioceptive, visual and verbal cues were provided as the basis for the intervention.
2.3. Experimental protocol

The choice of tasks for the experimental protocol was largely based on results from a previous study conducted in this laboratory on the effects of Pilates training, as well as studies on the biomechanical differences between healthy subjects and others with neck/shoulder pain, with the hypothesis that the chosen tasks would discriminate between levels of functional status, i.e. that they would be sensitive to AT training-related improvements. Initially, participants performed reference muscle contractions with the dominant (right) arm and during which electromyographical (EMG) data was collected. The participant sat straight in a chair with their torso and waist secured by straps, had their feet crossed and resting underneath the chair and their right elbow flexed approximately 90°, with their dominant elbow resting on the exercise head of the Baltimore Therapeutic Equipment Work Simulator 2™ (BTE Work SIM), (BTE-Tech©, Baltimore, MD, USA). The shoulder was abducted approximately 30° and strapped to a locked bar emanating from the exercise head of the BTE Work SIM. The participant was instructed to look straight ahead and perform a maximal shoulder external rotation against the locked bar which also elicited strong activation of the upper trapezius and infraspinatus muscles. Then, the participant sat on a stool with arms resting
on a table and shoulders flexed to $90^\circ$. The participant was instructed to look straight ahead and extend their shoulders by pressing down into the table, with the table providing resistance, thus eliciting strong activation of the serratus anterior muscle. Then participants sat on the chair of the BTE Multi Cervical Unit™ (MCU), (BTE-Tech©, Baltimore, MD, USA), with the bottom of the MCU load cell positioned at the external occipital protuberance of the skull. The positions and heights of the chair’s seat, back rest and arm rests were adjusted to the participants’ size, posture and height. Shoulder and waist straps secured the participants to the chair. Strong activation was elicited from the cervical erector spinae muscle while the participant extended the neck against the load cell which provided isometric resistance. For each of these tasks, three trials were performed and participants were given one minute rest in between each trial.

All subsequent tasks were performed in random order. For the static seated posture task, participants sat on a stool with their hands on their thighs and were instructed to look straight ahead and sit naturally for 10 seconds. In the seated and weighted shoulder flexion task (Fig. 2a), participants sat naturally on the same stool, looking straight ahead and held a five pound dumbbell in their right hand, forearm pronated, elbow straight, with their contralateral arm relaxed at their side. Upon a verbal cue, the participant flexed the shoulder once, raising the dumbbell as high as they could go and returned to the starting position. Five trials of the weighted shoulder flexion task were performed, with one minute rest in between. The one minute typing task (Fig. 2b) consisted of the participant sitting on the stool with a table at 75.9cm in height and a laptop placed in front of them. Participants were asked to adjust the laptop to what they thought would be a comfortable position. Laptop position was recorded and was replicated during the second experimental session. Participants were then asked to sit naturally, look at a text on a word processing document and type the copied text below the original text. Stool height for the above three tasks was fixed at 45.5cm.
For the maximal reaching speed task, participants stood and with their dominant arm abducted at the shoulder, moved the arm in a horizontal plane at shoulder height by flexing and extending their elbow as fast as they could between a proximal and a distal target for 10 seconds. Targets were equipped with touch sensors that produced analog signals to allow calculation of average speed. Both targets were placed in line with the midline of the body, at shoulder height. A laser beam was used to align the proximal and distal targets with the midline of the body. The distal target was placed at the furthest reach of the index finger and the proximal target was placed at 30% of the furthest distance reached. A mesh barrier was placed under the elbow range of motion to insure that the entire arm moved in a horizontal plane.

Next, the BTE Work SIM was used to record three trials with the dominant arm for each of three shoulder range of motion (ROM) tasks: flexion, abduction, and external rotation. The external rotation task required the participant to assume the same position as that described above for the first shoulder muscle reference contraction. Then, the participant was instructed to
look straight ahead and perform one external rotation as far as they could go and return to the starting position. The shoulder abduction task had participants using the same seated set-up except that the BTE Work SIM exercise head was aligned with the glenohumeral joint in the frontal plane with a straight bar secured to the arm at the upper arm and the wrist of the participant. They were then asked to abduct the arm as far as they could while keeping the elbow straight and then return to the starting position. The third ROM task, shoulder flexion, had the same set-up as the abduction task with exception that the chair was rotated a quarter turn clockwise such that the axis of rotation of the BTE Work SIM was still in alignment with the glenohumeral joint but in the sagittal plane (Fig. 3). The participant was required to flex the shoulder as high as possible and return to the starting position. These three tasks were randomized and participants were given a 30 second rest in between each trial.

![Fig. 3. Shoulder flexion ROM task.](image)

Neck ROM trials consisted of left rotation, right rotation, left lateral flexion and right lateral flexion of the head and were performed using the MCU (described above). The four tasks were randomized and each task was performed three times with a 30 second rest in between each trial. The pivot point of the halo was set to align with the participants’ C5/C6. Head braces were then secured from the halo to the participants’ head and a locking pin was removed. For each
movement, participants were asked to move their head without raising or lowering their shoulders, manoeuvring their torso away from the back rest or using the arm rest for leverage, and then return to the neutral position. For rotation trials, the halo was set at $10^\circ$ flexion, according to the system’s user manual. The participants were asked to turn their head as far as they could go, towards the left or the right. For the lateral flexion trials, participants were seated in the same manner as the previous task but the halo was turned to $90^\circ$ right rotation with the flexion angle set to zero before securing the head. The participants were asked to flex their neck to the side (left or right) as far as they could go, such that they brought their ear as close as possible to their shoulder. All equipment positions were recorded and replicated during the post-training experimental protocol.

Finally, a modified version of a questionnaire previously used (Emery et al., 2009) was administered to assess the AT participants’ level of satisfaction and enjoyment with the training, and what outcomes were expected from the training versus what was achieved.

2.4. Data acquisition

The Telemyo 900 Noraxon EMG system was used to record muscle activity. Data of four muscles was sampled at 1080 Hz and recorded for all trials of the reference contractions, typing and weighted shoulder flexion tasks. The skin was cleaned with an alcohol swab and if necessary, shaved for improved signal transmission. The locations of the bipolar surface Ag/AgCl electrodes (Ambu, De) for the cervical erector spinae (CES), upper trapezius (UT), infraspinatus (INF) and serratus anterior (SA) muscles were selected according to the Basmajian method (Basmajian and Blumenstein, 1983). Electrodes were placed on the right (dominant) side of the body and a ground electrode was placed on the left anterior acromion.

Tri-dimensional kinematic data was sampled at 120Hz and acquired using near infrared cameras (Vicon 512 Motion Analysis System™, Oxford, UK) for the seated static posture, typing and weighted shoulder flexion tasks. Kinematic
analysis required the following anthropometric measures: height, weight and trunk segment thickness at the T1, T4, T10, and L3 vertebrae. The anatomical landmarks for reflective markers were as follows: scapular inferior angle, spine root of the scapula, scapular posterior acromion, right head of third metacarpal, right lateral epicondyle, left and right acromioclavicular joint, sternum, sacrum, right and left posterior superior iliac spine, S1, right and left L1 transverse process, T12 spinous process, right and left T8 transverse process, T6 spinous process, right and left T1 transverse process, C7 spinous process, right and left posterior sides of the head and right and left anterior sides of the head.

ROM data for the shoulder was acquired using the BTE Work SIM, a commercial dynamometry system frequently used in the rehabilitation and research settings to measure force output using strain gauges and displacements of the exercise head using rotary potentiometers. Reliability of the BTE Work SIM in measuring shoulder ROM in healthy participants has already been demonstrated (Lomond et al., 2009). The built-in software was used to acquire and store raw data on a text file which was then used for further analysis. Neck ROM data were acquired using the Multi-Cervical Unit (MCU) (BTE Technologies, Inc, Baltimore, MD), which is a system designed to quantify isometric neck force using strain gauge load cells and neck ROM using rotary potentiometers. Chiu and Lo (2002) have reported good reliability and validity for neck ROM measurements in healthy participants with the MCU. ROM values recorded by the MCU were stored and used for further analysis.

2.5. Data analysis

The marker position data was low-passed filtered (zero-lag second order Butterworth filter, 6 Hz). Kinematic data was analyzed using Bodybuilder software (Vicon Motion Systems Ltd., Oxford, UK) and Matlab software (MathWorks, Massachusetts, USA) to determine posture and movements at the cervical, thoracic and lumbar spine, scapula and shoulder. An average of the three scapular markers (posterior acromion, spine root and inferior angle) was calculated to determine scapula segment angle relative to the global space.
Scapular displacement was calculated relative to C7. Anterior tipping of the scapula is defined as the clockwise rotation in the sagittal plane, whereas upward scapula rotation is defined as a counter clockwise rotation in the frontal plane (Borstad and Ludewig, 2002; Ludewig and Cook, 2000; Lukasiewicz et al., 1999; Wu et al., 2005). Neck angle was determined relative to C7 with neck flexion defined as the rotation of the head segment on the C7 marker. Right shoulder flexion angles were defined as the angle of the humerus relative to the trunk (T1-S1) segment (Wu et al., 2005). Kinematics of the spine was analyzed by separating the trunk into three sub-segments; the lumbar segment (Lx, L1-S1), the lower thorax (LowTX, T8-L1) and the upper thorax (UpTx, T1-T6). The angle between the upper thoracic segment and the vertical was used to define thoracic kyphosis in the sagittal plane. For the typing and static seated posture tasks, kinematic analysis focused on average segment positions and angles to reflect postural data, whereas for the weighted shoulder flexion task we focused our kinematic analysis on linear and angular movement amplitudes, defined as the difference between the extreme positions (maximum, minimum) recorded during each trial.

EMG data analysis started with heartbeats being filtered out of each muscle activation signal. A reference heartbeat detected from one muscle signal was chosen and, with a cross correlation applied, corresponding heartbeat signals in the remaining three muscles were removed. EMG data was then filtered using a zero-lag second order bandpass filter (20-500 Hz) and full wave rectified. Maximal values of the root mean squares (RMS) of 100 millisecond (ms) windows for each EMG signal recorded during reference trials were used as normalization signals. During the weighted shoulder flexion task, the upward shoulder flexion phase was partitioned from the downward extension phase and 100ms windows were taken at 90° and 120° of the upward phase. RMS values of the 90° and 120° 100ms windows were then calculated for each muscle and were normalized against the peak RMS of the reference trials. The resulting values were thus expressed as a % reference RMS. EMG data were analyzed using Matlab software (MathWorks, Massachusetts, USA). Maximal reaching speed
data were obtained from touch sensors (Quantum Research Group Ltd.) producing analog signals. To study muscle activation during the maximal reaching speed trials, data of five consecutive reaches were taken from the middle part of the 10s recording, in order to avoid movement habituation (beginning reaches) and fatigue (end reaches) effects. Signal RMS values were calculated across all muscles for this part of the recording.

2.6. Statistical analysis

Statistical analyses were computed using Statistica, v.7 (Statsoft, Tulsa, OK, USA) software. Means for all trials in each task for each participant were calculated. For all outcome measures, the effects of AT training were calculated with a two way ANOVA with a between-subject factor of group (experimental, control) and a within-subject factor of time (time 2 = eight weeks after time 1) and statistical significance was set at p < 0.05. In the event of significant interactions or main effects, post-hoc Tukey tests were performed. T-tests for age, height, weight and time between laboratory assessments were also performed to verify group matching.

3. Results

T-tests for age, height, weight and time showed no statistically significant differences between these group characteristics.

3.1. Kinematics

Table 1 summarizes the kinematic findings related to posture in the static seated posture task. Statistical analysis revealed that there was a significant interaction effect in the upper thoracic segment angle (achieved power = 0.99) and right shoulder angle parameters (achieved power = 0.76) (Table 1). Post-hoc analyses revealed that there was a reduction in kyphosis at the upper thoracic segment at time 2 in the Alexander Technique (AT) training group, as the average flexed position of their upper thorax was reduced by approximately 5° (post-hoc $P = 0.011$). As for the control group, there was an increase in average thoracic
kyphosis angle of about 4° between times 1 and 2 (post-hoc $P = 0.046$). In addition, there was significant difference between AT training group time 2 and control time 2 (post-hoc $P = 0.00019$). However, there was also a group main effect ($P = 0.001$) in average thoracic kyphosis angle, with the control group showing generally more thoracic kyphosis than the AT training group (approx. 23° vs. 16°).

Analysis of the average right shoulder flexion angle revealed that there was a significant reduction by about 3° at time 2 in the AT training group, where there was an increase of about 4° in the control group. Post-hoc Tukey analysis revealed a significant difference between AT training group time 2 and control time 2 (post-hoc $P = 0.024$). In addition, a group effect was observed, with the control group exhibiting a higher average right shoulder flexion angle during static seated posture than that of the training group, by about 6°. None of the other kinematic parameters for the static seated posture task displayed any interaction or main effects.
Table 1
Mean characteristics (SD), and P-values of trunk and shoulder average positions during static seated posture task.

<table>
<thead>
<tr>
<th>Kinematic Parameters</th>
<th>Time 1 (mean(SD))</th>
<th>Time 2 (mean(SD))</th>
<th>Time X Group p&lt;</th>
<th>ME Time</th>
<th>ME Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>AT</td>
<td>C</td>
<td>AT</td>
<td></td>
</tr>
<tr>
<td><strong>Neck Angle (°)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>-23.31(14.49)</td>
<td>-18.88(8.65)</td>
<td>-24.36(9.32)</td>
<td>-16.41(8.28)</td>
<td>ns</td>
</tr>
<tr>
<td>Medial/Lateral flexion</td>
<td>-0.23(2.28)</td>
<td>2.6(4.83)</td>
<td>-1.35(4.6)</td>
<td>0.38(4.66)</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Right Shoulder Angle (°)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>13.09(6.2)</td>
<td>10.03(6.37)</td>
<td>17.29(10.23)</td>
<td>7.7(6.09)</td>
<td>.011*</td>
</tr>
<tr>
<td>abduction/adduction</td>
<td>-0.16(2.06)</td>
<td>-1.2(2.47)</td>
<td>-0.25(1.9)</td>
<td>-0.09(2.29)</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Scapular Position (cm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior/posterior displacement</td>
<td>16.9(31.75)</td>
<td>11.67(30.4)</td>
<td>15.05(23.53)</td>
<td>26.2(27.0)</td>
<td>ns</td>
</tr>
<tr>
<td>Medio-lateral displacement</td>
<td>-7.7(18.85)</td>
<td>-12.07(14.15)</td>
<td>-10.85(18.19)</td>
<td>-7.57(16.83)</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Scapular Segment Angle (°)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upward/Downward rotation</td>
<td>4.9(7.63)</td>
<td>3.35(4.44)</td>
<td>8.06(6.03)</td>
<td>1.1(5.7)</td>
<td>ns</td>
</tr>
<tr>
<td>Anterior/Posterior tipping</td>
<td>18.31(5.03)</td>
<td>14.8(7.06)</td>
<td>19.42(8.4)</td>
<td>13.88(5.98)</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Upper Thoracic Segment Angle (°)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medial/Lateral flexion</td>
<td>1.45(1.57)</td>
<td>0.36(2.58)</td>
<td>1.41(2.13)</td>
<td>1.19(2.39)</td>
<td>ns</td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>21.16(4.42)</td>
<td>18.4(7.3)</td>
<td>24.98(8.89)</td>
<td>13.64(5.36)</td>
<td>.000*</td>
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<tr>
<td><strong>Lower Thoracic Segment Angle (°)</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medial/Lateral flexion</td>
<td>0.95(2.39)</td>
<td>0.65(2.88)</td>
<td>-0.06(2.13)</td>
<td>2.55(1.86)</td>
<td>ns</td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>-0.88(3.33)</td>
<td>-1.82(4.15)</td>
<td>-0.52(3.95)</td>
<td>-1.7(2.19)</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Lumbar Segment Angle (°)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medial/Lateral flexion</td>
<td>0.08(2.74)</td>
<td>0.07(1.86)</td>
<td>0.16(2.13)</td>
<td>1.15(1.71)</td>
<td>ns</td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>2.2(7.48)</td>
<td>4.37(7.69)</td>
<td>0.79(6.21)</td>
<td>5.0(5.98)</td>
<td>ns</td>
</tr>
</tbody>
</table>

AT: Alexander Technique training group; C: Control group
Similar postural changes were observed in the typing task, with several interaction effects in average body angles. Table 2 shows a significant interaction effect for the upper thoracic flexion angle (achieved power = 0.96), with a decrease of 6.27° with time in the AT training group (post-hoc $P = 0.006$), and a small and insignificant increase (about 2°) in the control group. Post-hoc analysis also revealed a significant difference between AT training group time 2 and control time 2 (post-hoc $P = 0.018$).

There was also a significant interaction effect in the average right shoulder flexion angle (achieved power = 0.53), with the training group demonstrating a reduced average shoulder flexion by about 4°, and the control group showing the opposite trend, with an increase of about 3° between times 1 and 2. However, post-hoc analysis revealed no significant post-hoc comparisons.

In addition to changes in the sagittal plane posture, some slight changes were also observed in the frontal plane. The average upper thoracic segment angle saw a significant interaction effect (achieved power = 0.67), with post-hoc Tukey analysis showing a slight increase of about 1.8° in average medial flexion position (towards the right) in the AT group with time, with a slight decrease of about 1° with time in the control group. However, none of these post-hoc comparisons were significant. The average position of the lower thoracic segment angle also demonstrated a small but significant interaction effect (achieved power = 0.94) in medial flexion. A post-hoc analysis revealed a significant effect of time in the training group ($P = 0.011$), with an average leftward flexion angle of approximately 1.5° before training changing to an average rightward flexion angle of approximately 2° after training. In addition, a significant difference between AT training group time 2 and control time 2 (post-hoc $P = 0.033$) was observed.
Table 2
Mean characteristics (SD) and P-values of trunk and shoulder average positions during the static typing task.

<table>
<thead>
<tr>
<th>Kinematic Parameters</th>
<th>Time 1 (mean(SD))</th>
<th>Time 2 (mean(SD))</th>
<th>Time X Group p&lt;</th>
<th>ME Time</th>
<th>ME Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>AT</td>
<td>C</td>
<td>AT</td>
<td>p&lt;</td>
</tr>
<tr>
<td>Neck Angle (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>−8.31(11.34)</td>
<td>−3.67(8.61)</td>
<td>−5.92(5.19)</td>
<td>−5.52(9.41)</td>
<td>ns</td>
</tr>
<tr>
<td>Medial/Lateral flexion</td>
<td>−0.23(3.79)</td>
<td>1.8(4.1)</td>
<td>−0.3(4.05)</td>
<td>−0.47(4.55)</td>
<td>ns</td>
</tr>
<tr>
<td>Right Shoulder Angle (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>22.7(13.73)</td>
<td>25.71(11.71)</td>
<td>25.46(14.78)</td>
<td>22.03(11.17)</td>
<td>.046*</td>
</tr>
<tr>
<td>Abduction/Adduction</td>
<td>0.18(2.14)</td>
<td>0.21(3.52)</td>
<td>0.27(2.42)</td>
<td>1.06(1.81)</td>
<td>ns</td>
</tr>
<tr>
<td>Scapular Position (cm)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Anterior/posterior displacement</td>
<td>28.33(35.77)</td>
<td>26.42(30.54)</td>
<td>24.14(28.66)</td>
<td>44.15(31.53)</td>
<td>ns</td>
</tr>
<tr>
<td>Medio-lateral displacement</td>
<td>−0.54(19.02)</td>
<td>−4.76(16.27)</td>
<td>8.35(29.86)</td>
<td>1.47(16.33)</td>
<td>ns</td>
</tr>
<tr>
<td>Scapular Segment Angle (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upward/Downward rotation</td>
<td>2.21(3.16)</td>
<td>2.19(4.93)</td>
<td>3.61(3.52)</td>
<td>−1.48(5.74)</td>
<td>ns</td>
</tr>
<tr>
<td>Anterior/Posterior tipping</td>
<td>22.02(9.59)</td>
<td>18.56(8.35)</td>
<td>22.57(9.34)</td>
<td>16.77(5.74)</td>
<td>ns</td>
</tr>
<tr>
<td>Upper Thoracic Segment Angle (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medial/Lateral flexion</td>
<td>1.42(2.58)</td>
<td>0.17(2.68)</td>
<td>0.41(2.57)</td>
<td>2.0(2.32)</td>
<td>.021*</td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>25.71(10.53)</td>
<td>24.18(10.8)</td>
<td>28.32(11.57)</td>
<td>17.91(6.43)</td>
<td>.001*</td>
</tr>
<tr>
<td>Lower Thoracic Segment Angle (°)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medial/Lateral flexion</td>
<td>0.43(2.3)</td>
<td>−1.49(2.91)</td>
<td>−1.23(2.5)</td>
<td>2.03(1.97)</td>
<td>.002*</td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>0.68(2.52)</td>
<td>−0.31(4.09)</td>
<td>0.46(3.54)</td>
<td>−0.42(2.53)</td>
<td>ns</td>
</tr>
<tr>
<td>Lumbar Segment Angle (°)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medial/Lateral flexion</td>
<td>−0.51(3.27)</td>
<td>−0.17(2.92)</td>
<td>−0.96(2.42)</td>
<td>0.32(1.11)</td>
<td>ns</td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>3.82(7.34)</td>
<td>4.73(8.01)</td>
<td>2.51(9.7)</td>
<td>4.44(5.9)</td>
<td>ns</td>
</tr>
</tbody>
</table>

AT: Alexander Technique training group; C: Control group

The weighted shoulder flexion task revealed no significant interactions in the spine, scapula or arm movement amplitude data due to training. However, a group effect ($P = 0.033$, achieved power = 0.59) was observed in the flexion of...
the lumbar segment with the training group displaying a higher movement amplitude of about 2° achieved during the weighted shoulder flexion task versus approximately 0.2° for the control group. In addition, there was a time effect ($P = 0.01$, achieved power = 0.77) for scapular displacement amplitude, with both groups displaying an increase in lateral scapular displacement of approximately 4cm between time 1 and time 2.

3.2. EMG

For the weighted shoulder flexion task, at 120° of shoulder flexion, there was a significant group x time interaction effect for the SA muscle, with the AT group showing increased activation of 29.7% after training (Table 3). However, post-hoc Tukey analysis revealed that this increase was not significant. Moreover, further analysis revealed that the SA activity during the reference contraction showed a time main effect (Table 4) with decreased SA activation levels at time 2 for the AT training group. Based on group average data, the AT training group showed a bigger decrease in SA activity with time of approximately 363 millivolts (mV), whereas it was a decrease of 62 mV for the control group. Despite this, analysis of the non-normalized SA activity at 120° still displayed a significant time x group interaction (Table 4), with a non-significant post-hoc comparisons showing higher EMG after AT training, similarly to the results of the normalized EMG analysis showed in Table 3.
Table 3
Means EMG RMS (SD), expressed in % EMG RMS of reference contraction levels and P-values of muscle activation amplitude during upward phase of weighted shoulder flexion with a 5-lbs. weight.

| Degrees | Muscles               | Time 1 (mean|SD)) | Time 2 (mean|SD)) | Time X Group p< | ME Time | ME Group |
|---------|-----------------------|----------|----------|---------------|---------|----------|
| 90      | Cervical Erector Spinae | 73.89(29.7) | 53.74(36.1) | 64.04(50.0) | 49.9(29.1) | ns       | ns       | ns       |
|         | Upper Trapezius       | 83.16(21.12) | 70.68(32.77) | 95.45(29.35) | 75.09(46.1) | ns       | ns       | ns       |
|         | Infraspinatus         | 44.06(23.86) | 51.67(29.28) | 52.54(23.64) | 42.2(25.24) | ns       | ns       | ns       |
|         | Serratus Anterior     | 89.41(73.21) | 54.89(48.97) | 71.35(56.7)  | 84.53(39.04) | ns       | ns       | ns       |
| 120     | Cervical Erector Spinae| 70.62(30.83) | 51.23(32.39) | 60.01(42.74) | 53.78(28.1) | ns       | ns       | ns       |
|         | Upper Trapezius       | 80.67(24.42) | 62.92(27.57) | 91.98(30.29) | 67.61(37.5) | ns       | ns       | ns       |
|         | Infraspinatus         | 37.18(18.04) | 39.11(18.62) | 47.35(15.8)  | 32.63(9.18) | ns       | ns       | ns       |
|         | Serratus Anterior     | 116.26(101.97) | 72.08(70.57) | 83.19(78.71) | 101.78(47.51) | p=.042 | ns       | ns       |

AT: Alexander Technique training group; C: Control group

Table 4
Serratus anterior means EMG (SD), expressed in Mv, and P values of muscle activation amplitude during reference contractions and weighted shoulder flexion task.

| Muscles   | Time 1 (mean|SD)) | Time 2 (mean|SD)) | Time X Group p< | ME Time | ME Group |
|-----------|----------|----------|---------------|---------|----------|
| C         | AT       | C        | AT            |         |         |
| EMG       |          |          |               |         |         |
| Reference |          |          |               |         |         |
| contractions |        |          |               |         |         |
| Serratus  | 769.7(558.73) | 1015.17(633.85) | 70.5(460.89) | 651.49(270.24) | ns       | 0.024    | ns       |
| anterior  |          |          |               |         |         |
| Non-      | 650.45(311.58) | 573.30(220.95) | 487.05(299.09) | 667.1(262.81) | p=.039   | ns       | ns       |
| Normalized |          |          |               |         |         |
| EMG       |          |          |               |         |         |
| Flexion   |          |          |               |         |         |
| 120°      |          |          |               |         |         |
| Serratus  |          |          |               |         |         |

AT: Alexander Technique training group; C: Control group
Analysis of muscular activity during the typing task yielded no significant effects of AT training on the activities of muscles studied here, as shown in (Table 5).

### Table 5
Means EMG RMS (SD), expressed in % EMG RMS of reference contraction levels, and $P$ values of muscle activation amplitude during typing task.

<table>
<thead>
<tr>
<th>Task</th>
<th>Muscles</th>
<th>Time 1 (mean(SD))</th>
<th>Time 2 (mean(SD))</th>
<th>Time X Group p&lt;</th>
<th>ME Time</th>
<th>ME Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>AT</td>
<td>C</td>
<td>AT</td>
<td></td>
</tr>
<tr>
<td>Typing</td>
<td>Cervical erector Spinae</td>
<td>10.41(6.51)</td>
<td>8.96(4.85)</td>
<td>8.03(3.56)</td>
<td>8.13 (6.15)</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>Upper Trapezius</td>
<td>8.89(4.3)</td>
<td>10.5(5.1)</td>
<td>10.94(6.98)</td>
<td>13.48(12.2)</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>Infraspinatus</td>
<td>5.08(2.26)</td>
<td>6.15(6.48)</td>
<td>4.87(2.76)</td>
<td>4.0(2.02)</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>Serratus anterior</td>
<td>5.65(3.15)</td>
<td>4.24(3.73)</td>
<td>5.02(3.36)</td>
<td>4.77(3.95)</td>
<td>ns</td>
</tr>
</tbody>
</table>

AT: Alexander Technique training group; C: Control group

3.3. *Shoulder range of motion tasks*

Statistical analysis revealed a significant interaction effect on shoulder flexion ROM (Table 6; achieved power = 0.62). The flexion ROM increased significantly by $9^\circ$ for the group that received the AT training, as shown in the significant post-hoc analysis ($P = 0.046$). A time main effect was also observed (achieved power = 0.9) in the abduction ROM task, with higher ROM at time 2 for both the control and AT groups. The increase in abduction ROM for the AT training group was approximately $12^\circ$, whereas it was approximately $7^\circ$ for the control group.
Table 6
Means (SD) and P-values of shoulder range of motion tasks.

<table>
<thead>
<tr>
<th>Task</th>
<th>Time 1 (mean(SD))</th>
<th>Time 2 (mean(SD))</th>
<th>Time X Group p&lt;</th>
<th>ME Time</th>
<th>ME Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>AT</td>
<td>C</td>
<td>AT</td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>197.8(9.81)</td>
<td>189.7(12.45)</td>
<td>196.2(12.55)</td>
<td>198.7(7.61)</td>
<td>.028*</td>
</tr>
<tr>
<td>External Rotation</td>
<td>132.8(10.27)</td>
<td>135.1(14.95)</td>
<td>130.4(14.56)</td>
<td>134.8(14.82)</td>
<td>ns</td>
</tr>
<tr>
<td>Abduction</td>
<td>191.1(12.24)</td>
<td>185.3(12.5)</td>
<td>198.4(8.11)</td>
<td>197.7(7.41)</td>
<td>ns</td>
</tr>
</tbody>
</table>

AT: Alexander Technique training group; C: Control group

3.4. Neck range of motion

Statistical analysis did not reveal any significant training effects on neck ROM (Table 7). However, a time main effect was observed for the left rotation task (achieved power = 0.7). A post-hoc Tukey analysis revealed that only the experimental group had significantly increased neck left rotation ROM over time ($P = 0.028$). The AT training group increased neck leftward rotation by approximately 5°, whereas it was approximately 1° for the control group.

Table 7
Means (SD) and P-values of neck range of motion tasks.

<table>
<thead>
<tr>
<th>Task</th>
<th>Time 1 (mean(SD))</th>
<th>Time 2 (mean(SD))</th>
<th>Time X Group p&lt;</th>
<th>ME Time</th>
<th>ME Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>AT</td>
<td>C</td>
<td>AT</td>
<td></td>
</tr>
<tr>
<td>Left Rotation</td>
<td>65.0(10.47)</td>
<td>63.0(4.58)</td>
<td>66.0(10.58)</td>
<td>68.2(6.84)</td>
<td>ns</td>
</tr>
<tr>
<td>Right Rotation</td>
<td>75.1(10.78)</td>
<td>73.1(9.98)</td>
<td>76.5(12.86)</td>
<td>74.9(10.11)</td>
<td>ns</td>
</tr>
<tr>
<td>Left lateral flexion</td>
<td>49.7(6.29)</td>
<td>47.9(7.83)</td>
<td>49.6(7.85)</td>
<td>48.6(5.91)</td>
<td>ns</td>
</tr>
<tr>
<td>Right lateral flexion</td>
<td>53.0(3.32)</td>
<td>48.8(6.58)</td>
<td>54.3(5.31)</td>
<td>50.6(6.71)</td>
<td>ns</td>
</tr>
</tbody>
</table>

AT: Alexander Technique training group; C: Control group
3.5. Maximum reaching speed task

Statistical analysis did not reveal any significant effects on maximum reaching speed, nor were there any effects observed in the muscle activation of the CES, UT, INFRA and SA during that task.

3.6. Questionnaire

A review of the questionnaire responses revealed that 60% of respondents found the AT training ‘very enjoyable’ and 40% of the respondents found the training to be between ‘moderately enjoyable’ and ‘very enjoyable’. Table 8 demonstrates what the AT participants were expecting from the AT training and Table 9 demonstrates what the participants felt they received from the Alexander technique training. A comparison of both tables suggests that participants gained more than expected in every category, with the exception of improved posture (100% in both expected and achieved gains).

Table 8
Expected outcomes of AT training.

<table>
<thead>
<tr>
<th>Effects</th>
<th>%</th>
<th>Effects</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Physical strength (upper body)</td>
<td>10</td>
<td>6.) Meet new people</td>
<td>40</td>
</tr>
<tr>
<td>2.) Flexibility (upper body)</td>
<td>50</td>
<td>7.) Learn a new physical activity</td>
<td>30</td>
</tr>
<tr>
<td>3.) Physical fitness</td>
<td>10</td>
<td>8.) Physical strength (lower body)</td>
<td>10</td>
</tr>
<tr>
<td>4.) Postural improvement</td>
<td>100</td>
<td>9.) Flexibility (lower body)</td>
<td>20</td>
</tr>
<tr>
<td>5.) Relaxation</td>
<td>60</td>
<td>10.) Be able to sit and type for longer periods</td>
<td>40</td>
</tr>
</tbody>
</table>
Table 9
Achieved outcomes of AT training.

<table>
<thead>
<tr>
<th>Effects</th>
<th>%</th>
<th>Effects</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Physical strength (upper body)</td>
<td>30</td>
<td>6.) Meet new people</td>
<td>70</td>
</tr>
<tr>
<td>2.) Flexibility (upper body)</td>
<td>60</td>
<td>7.) Learn a new physical activity</td>
<td>80</td>
</tr>
<tr>
<td>3.) Physical fitness</td>
<td>30</td>
<td>8.) Physical strength (lower body)</td>
<td>30</td>
</tr>
<tr>
<td>4.) Postural improvement</td>
<td>100</td>
<td>9.) Flexibility (lower body)</td>
<td>30</td>
</tr>
<tr>
<td>5.) Relaxation</td>
<td>70</td>
<td>10.) Be able to sit and type for longer periods</td>
<td>50</td>
</tr>
</tbody>
</table>

Further to the questionnaire results above, some comments from the participants of the AT group include, but are not limited to: less shoulder tension after AT training, better quality of music when using their musical instrument, increased body awareness, and improved ability to recognize bad habits and self correct. Indeed, as one participant claimed, “I was able to also make some clearer connections between mental and physical states with regard not only to how mental stress feeds into physical stress, but also vice versa, which was kind of new to me. I.e.: if my body is a certain way (out of habit or whatever), then my mental state might come to reflect that, so if I wear my shoulders around my ears, that may cause stress, and not just the other way around.”

4. Discussion

The purpose of this study was to investigate the effects of an Alexander Technique (AT) training program on the biomechanics of the neck, shoulder and spine. Previous studies have shown AT training to have a positive effect on balance, lateral trunk flexion symmetry and low back pain in some cohorts with Parkinson’s, older women, and low back pain (Caciatoare et al., 2005; Dennis, 1999; Little et al., 2008; Stallibrass et al., 2002). However, to the author’s knowledge, no study has examined the effects of AT training on neck and shoulder biomechanics and posture in healthy participants. For kinematic and
electromyographical (EMG) variables, we began with a static seated posture task to measure the segment angles of the head, neck, scapula, and thoracic and lumbar spine in order to reflect static postural alignment. We chose to implement a typing task due to an increase in computer use in the general population and its association with musculoskeletal disorders (Bergqvist, 1993; Bernard et al., 1994; Kamwendo et al., 1991; Tittiranonda et al., 1999). Combined, neck and shoulder pain prevalence is estimated to be as high as 31% in office workers who use computers, and as high as 50% worldwide in the workplace (Edmondston et al., 2007; McLean, 2005). In addition to the typing task we chose a weighted shoulder flexion task, a movement that incorporates segmental movement with stabilization of the cervical and thoracic spine and of the shoulder girdle. A study from our laboratory had previously shown that scapular and upper spine biomechanics was changed after Pilates training, with smaller scapula and trunk movements during the shoulder flexion task indicating improved core stabilization during limb movements after Pilates. It is suggested that muscle imbalances and misaligned cervical and thoracic spine can contribute to scapular dyskinesis and thus alter scapulohumeral rhythm (Szeto et al., 2005a). Due to the suggested relationship between neck disorders and shoulder disorders (Andersen et al., 2003; Szeto et al., 2005a, 2005b), and given that one of the goals of the AT training is freedom of limbs from a stable trunk, we also hypothesized that we would see increased maximal reaching speed and active neck and shoulder range of motion (ROM) following AT training. Previous studies from our laboratory had also shown that people with neck/shoulder pain were not able to complete the maximal reaching speed task replicated in the current study as quickly, in accordance to the results of impaired arm movement speed in another study of neck/shoulder pain (Hagberg et al., 2000). Finally, joint range of motion has frequently been used as an outcome measure of impairment for a variety of musculoskeletal conditions, including those of the neck and shoulder. Therefore, a maximal reaching speed task and ROM tasks of shoulder flexion, abduction and external rotation, as well as neck rotation and lateral flexion were also included in the protocol from which to extract possible outcome measures for the effects of AT training.
4.1. Neck and shoulder joint ROM

Neck ROM results show no significant effect of AT training. However, there was a tendency towards an increase in left rotation ROM. In addition, a time main effect was observed for the left rotation task (achieved power = 0.7), with post-hoc analysis showing that both groups had significantly increased neck left rotation ROM over time. However, based on group average data, it seems that the AT training group is driving this main effect since the increase in the AT training group was approximately 5°, whereas it was approximately 1° for the control group. Perhaps one reason for the increased left neck rotation ROM for the AT training group may be due to a decrease in muscle tension of the right upper trapezius, sternocleidomastoid and splenius muscles in the right hand dominant individuals, although we didn’t measure activity of these muscles during the task. Nevertheless, one theory for no significant interaction effect for neck rotation may be that despite the ability of the neck ROM assessment system of the multi cervical unit (MCU) to isolate head and neck motion from the rest of the spine, the MCU does not fully replicate the natural setting of turning one’s head. The correct procedure for ROM testing with the MCU states that the participant must have their torsos/shoulders and hips fastened to prevent their motion. Therefore, the participant is closely secured to the seat of the MCU and does not perform neck ROM tasks within the context of their own natural posture. In addition, in AT training, participants are taught to move the head with as little neck muscle tension as possible; however, head movements during training are typically done without resistance, as during everyday activities. While the MCU was set to minimal resistance during the ROM trials, the pulley system did offer some inherent resistance, albeit small. Nevertheless, within the context of the MCU securing arrangements, there were no significant changes due to the AT training, despite an increase with time in both groups, and a larger one in the AT group.

Of the three shoulder ROM tasks, the shoulder flexion task saw a significant training effect resulting in an increase in ROM. We posit that the
decreased thoracic kyphosis associated with the seated posture after AT training (see later) aided in shoulder flexion, which is supported by literature indicating that kyphosed posture limits shoulder ROM and an erect posture can significantly increase shoulder flexion ROM (Bullock et al., 2005). Moreover, the results of Finley and Lee (2003) noted that during humeral elevation in healthy adults, there were decreases in lateral rotation of the scapula and posterior tipping as a result of increased thoracic kyphosis. Therefore, there may have been improved upward rotation of the scapula during the shoulder flexion ROM task, thus improving overall scapulohumeral rhythm. Conversely, no changes were observed for the abduction or external rotation tasks, which goes against this theory, although there was a main time effect for abduction, with larger increases with time in the AT group. In addition, kinematic data was not collected during the shoulder ROM tasks so that it is difficult to suggest any positive changes in shoulder ROM attributed to scapular and thoracic kinematics; moreover, subjects were seated on a chair with a backrest during shoulder ROM trials, which in principle should have insured a straight back, although the back rest was only as high as approximately the mid back, which could have allowed some variation in upper spine posture between sessions. In summary, we show evidence that AT training affected shoulder ROM and we suggest that the mechanisms for this change may be related to other changes along the spine, although more detailed analyses should be conducted to strengthen this evidence.

4.2. Shoulder and spine kinematics

Decreases in thoracic kyphosis as well as in shoulder flexion angle were observed in the typing and static seated posture tasks after AT training. These results are in accordance with one of the main goals of the AT, which is to improve upper spine alignment. These findings support results from Emery et al. (2009) following a similar training protocol with Pilates as the intervention and a shoulder flexion task similar to ours as the experimental test, although for our weighted shoulder flexion task we did not observe any kinematic changes occurring at the shoulder after AT training. Research has shown that lateral
rotation of the scapula and posterior tipping decrease as a result of increased thoracic kyphosis during humeral elevation in healthy adults (Finley and Lee, 2003). Thus, inefficient upward rotation of the scapula during shoulder elevation can diminish overall scapulohumeral rhythm. Given this information, we hypothesized that we would see changes in scapular kinematics following AT training. However, in our study, there were no changes in scapular kinematics, which is in agreement with studies on the effects of stretching, strengthening and postural training interventions on scapular kinematics and resting posture (McClure et al., 2004; Wang et al., 1999). In addition, there were no significant changes due to the AT training for the neck angle or any other kinematic parameter during the weighted shoulder flexion task.

One major explanation for the lack of significant effect of AT training on our measured variables is that it is possible that our asymptomatic subjects did not require significant improvements in many of these parameters to achieve the experimental tasks, especially if they displayed significant improvements in other parameters such as kyphosis, which may have been sufficient as a main beneficial effect of AT to insure overall satisfactory task accomplishment. Also, changes in other parameters such as the decrease in average shoulder angle during the typing and static seated posture tasks were relatively minute and likely not clinically meaningful, but may still be attributed to the decrease in kyphosis thereby drawing the humerus closer to the trunk. In addition, a slight medial flexion of the upper and lower thoracic segments during the typing task also emerged to be significant in the AT training group, but minimal in nature (approximately $2^\circ$ and $4^\circ$ respectively) and may reflect a slight postural realignment after an decrease in thoracic kyphosis (upper thoracic segment) following AT training.

4.3. EMG

The demand from the neck extensors in supporting the weight of the head can change markedly from a change as small as $5^\circ$ in neck flexion angle (Straker, Jones, and Miller, 1997); and one of the main emphases during AT training is on achieving better, and tension-free, neck alignment. Therefore, we hypothesized
that there would be a difference in cervical erector spinae muscle activation following training. However, we did not observe any differences in cervical erector spinae (CES) muscle activation for any of the tasks, consistent with the absence of change in neck kinematics. Moreover, changes in upper trapezius (UT) activity were not observed in our study, which is in agreement with Caneiro et al. (2009) who, when studying three different thoraco-lumbar sitting postures (slumped, thoracic upright, and lumbo-pelvic upright), observed no significant differences in the UT muscle activity between the postures thus possibly requiring a greater difference in sitting posture in order to elicit significant changes in UT muscle activity (Schüldt et al., 1987). At 120° of shoulder flexion during the weighted shoulder flexion task, there was a group x time interaction effect for the serratus anterior (SA) muscle, with a trend towards increased activity for the AT training group, suggesting muscular patterns of scapular stabilization. The SA muscle has been shown to be active during stabilization of the scapula (Dvir and Berme, 1978; Ebaugh, McClure, and Karduna, 2005; Warner and Navarro, 1998), and deficits in SA activation patterns may be associated with a variety of shoulder symptoms. Indeed, SA impairment and related abnormal scapular kinematics has been implicated as one of a number of risk factors for shoulder pathologies such as shoulder impingement syndrome (SIS) and subacromial impingement syndrome (SAIS) (Hébert et al., 2002; Szeto et al., 2005a, 2005b), and these studies have highlighted posture, in part, for its role in functional and impaired shoulder and neck kinematics. Scapular muscle imbalances, such as those associated with weakness of the upper and lower trapezius and SA muscles, have been suggested as a contributing factor for scapular dyskinesis in a number of studies (Cools et al., 2007; Michener et al., 2003) and may alter glenohumeral kinematics, resulting in mechanical dysfunction, SAIS, and supraspinatus outlet stenosis (Lukasiewicz et al., 1999; Michener et al., 2003). Evidence of impaired motor patterns, possibly due to altered neuromuscular strategies, arose in a study observing the activity pattern of shoulder muscles in participants with and without SAIS. Diederichsen et al. (2009) observed less SA activity during abduction and external rotation of the symptomatic shoulder in people with SAIS when
compared with healthy participants. Moreover, scapulohumeral rhythm is altered in the 60°–150° range of glenohumeral motion when the SA is fatigued (McQuade et al., 1998). This is significant owing to research that implicates this same mid range as that when subacromial impingement can occur (Michener et al., 2003), thus highlighting the belief that proper muscle activation is conducive to normal scapulohumeral rhythm.

The lack of significant effects for the maximal reaching task with respect to maximal velocity and muscle activity may be attributed, in part, to the philosophy of the AT. We hypothesized that the AT would allow for increased maximal velocity and changes in neck/shoulder muscle activity during this task, since one of the focuses of the AT is the reduction of tension to allow a freer movement of the limbs, unlike Pilates, for example, which concentrates on core strength before limb control (Emery et al., 2009). However, we did not observe any effects of AT training related to this experiment. It is possible that the task was not challenging enough to elicit such change, especially since all of our subjects were healthy and could easily perform the task, whereas in our previous experiment with injured people, subjects had difficulty with the task and compensated with other muscles and joints when performing the task (Lomond et al., submitted). From this, we can conclude that maximal reaching speed may be an adequate outcome measure for pain and disability but may not be challenging enough as an outcome measure for function in healthy individuals undergoing AT training.

4.4. Experimental Limitations

Despite our efforts to maximize the motion capture system’s potential (i.e. participants using skin tight clothing or fixing loose-fitting clothing to the skin using double-sided tape, daily calibration, taping down of wires and any other items that could produce movement artefact), a limitation of the study is that for spine and scapula range of motion measurements, the displacements were rather small. Given the spatial resolution of the system (approximately less than 2 mm, corresponding to between 1° and 2° for our experimental angular motions
(Kakihana et al., 2005)), some of the observed displacements likely were within a range smaller than what we can say with confidence is a true displacement. As such, differences in the small medio-lateral average spine angles, while statistically significant, can be disregarded as clinically meaningful. Finally, constraints imposed by the limited number of motion capture cameras (6) and relatively small sample size may have also adversely affected the experimental results.

4.5. Alexander Technique

The results of our study suggest that AT training may influence some biomechanical variables related to posture, scapular stabilization, scapulohumeral rhythm and shoulder ROM. The aim of the Alexander Technique is to facilitate students to be more kinaesthetically aware of their posture and muscle tension and to make changes to problematic habitual movement patterns (Jain et al., 2004). This theory is in agreement with Diederichsen et al. (2009), who recommended as an integral part of a rehabilitation program greater focus on motion awareness to modify muscle activation patterns in people with shoulder impingement in addition to strengthening of the rotator cuff and scapular upward rotators. Moreover, the health care system has recently turned its attention to the importance of promoting strategies for self health awareness (Ontario Government, 2006) in patients (management) as well as healthy individuals (prevention), so as to avoid over-burdening the health care system. The AT falls well within this new focus and, as such, needs to be studied further in order to truly assess its impact on human health.

Since a large part of the AT focuses on the head, as a part of the head, neck, and back relationship centered approach, the premise of AT largely emphasises the importance of the head and cervical spine alignment in overall musculoskeletal health. Researchers have suggested that postural education and correction ought to be a part of treatment and prevention for cervical headaches (Watson and Trott, 1993). In addition, the importance of postural training for patients with temporomandibular disorders, who tend to demonstrate a forward
head posture, has also been highlighted (Sonnesen, Bakke, and Solow, 2001; Wright, Domenech, and Fischer, 2000). However, not all studies agree on the relationship between neck/shoulder biomechanics and symptoms. Hanten, Olson, Russell, Lucio, and Campbell (2000) found that there was no significant difference in resting head posture between healthy and neck pain patients. This is supported by Grimmer (1996) who suggested that it matters not what a person’s cervical resting posture is with regards to neck pain, whether an individual displays extreme cervical excursion or close to the population average, Grimmer (1996) found no association between the two. Regardless, it is important to highlight the benefits of neutral alignment versus non-neutral alignment. As a direct consequence of postural mechanics, there is less muscle activity (sternocleidomastoid, masseter, cervical erector spinae, levator scapulae, upper trapezius, posterior deltoid, supraspinatus and rhomboid major muscles) required for corrected, vertically aligned sitting posture than there is for forward head posture (McLean, 2005). In addition, the rounded shoulder and forward head posture has been shown to be the very same posture that clinical patients exhibit when reporting neck/shoulder pain (Szeto et al., 2002). As suggested in the literature, kyphosed posture limits the shoulder ROM, and an erect posture can significantly increase the shoulder flexion ROM (Bullock et al., 2005). An increase in thoracic kyphosis can contribute to inefficient upward rotation of the scapula during shoulder elevation and can diminish overall scapulohumeral rhythm (Finley and Lee, 2003), thus the need for proper vertebral alignment.

Finally, further confounding the issue on the impact of AT training on neck/shoulder health, the effect of gender on neck/shoulder health is at the moment equivocal. Some studies report that men and women tend to have similar head and shoulder posture in the sagittal and frontal plane (Raine and Twomey, 1997) while Hanten et al. (2000) suggest that gender differences do exist, with men, who generally tend to have a larger head size, also displaying a more forward resting head posture. Given that we saw no significant differences in neck ROM, CES activity, head and neck kinematics, and found inconclusive results in the literature, it is possible that effects of training could have been masked by
gender differences within the data of each group. Further research is needed to better understand the impact of AT training on the neck/shoulder relationship, with symptomatic and asymptomatic populations of both genders.

5. Conclusion

The results of our study show that 20 lessons of Alexander Technique (AT) over a period of eight weeks decreased thoracic kyphosis in a computer typing and in a static seated posture task, as well as increased shoulder flexion range of motion (ROM). In addition, the serratus anterior muscle displayed an increase in muscle activity suggesting an increase in stabilization of the scapula at 120° during a weighted shoulder flexion task. AT training did not affect neck ROM and no changes in motion of the head, trunk and shoulder segments were observed in the weighted shoulder flexion task. These results partially support our hypothesis that the AT training is effective at improving upper thoracic posture and some aspects of shoulder ROM and stability within the conditions of our study. Considering the relationship between thoracic alignment, biomechanical function of the shoulder joint and shoulder pain, our results could support the use of AT as a preventative and self health care method for healthy individuals. However, further research is needed to measure the effects of the AT on arm and spine biomechanics of men and women with neck/shoulder symptoms.

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CONCLUSION

The current research reviews the effects of an eight week, 20-lesson Alexander Technique (AT) training program on neck and shoulder biomechanics and posture in healthy people. Our results showed that AT training decreased thoracic kyphosis during a typing and a static seated posture task, increased shoulder flexion ROM, and increased serratus anterior muscle activity at 120° during a weighted shoulder flexion task, suggesting an increase in scapular stabilization mechanisms. Under the conditions of our study, our results support our initial hypothesis that AT training improves upper thoracic posture, scapular stability and shoulder flexion ROM. A literature review has highlighted the relationships of the cervical and thoracic spine, neck and shoulder pain, biomechanical function of the shoulder joint and scapulohumeral rhythm. In light of these relationships and our current results within this study, it is appropriate to suggest that the AT may have some clinical benefit as a rehabilitation approach for neck/shoulder disorders and also as a preventative, self awareness approach. Our results may prove beneficial to the leisure and work communities that use computers, since posture appears to be a risk factor for musculoskeletal disorders and considering that maintaining work-specific postures with static muscle activation is significantly associated with chronic neck and shoulder disorders. Moreover, the increase in ROM in shoulder flexion and possibly scapular stabilization is also useful given the frequency of shoulder flexion in work and day to day activities. Hence, the populations who are at risk of developing work-related, as well as non-work-related musculoskeletal disorders may benefit from AT training. This study is a first step in validating the effectiveness of AT among healthy subjects. Further research is required to quantify the effects of AT training on the arm and spine biomechanics in larger asymptomatic as well as symptomatic populations of both genders. These subsequent studies are necessary in order to provide evidence-based data to support the use of AT as a health management approach. If further studies confirm significant effects of AT on posture and motion, this could: provide an enlightening perspective for the primary care community in its approach to chronic neck/shoulder pain care; lend support to postural and self-
training techniques to reduce the amount of the money currently spent on health insurance claims and lost productivity experienced in workplaces; and perhaps most importantly, leave people with a healthier, pain-free and higher standard of daily living.


