



Altered spinal kinematics and muscle recruitment pattern of the cervical and thoracic spine in people with chronic neck pain during functional task



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ABSTRACT

Knowledge on the spinal kinematics and muscle activation of the cervical and thoracic spine during functional task would add to our understanding of the performance and interplay of these spinal regions during dynamic condition. The purpose of this study was to examine the influence of chronic neck pain on the three-dimensional kinematics and muscle recruitment pattern of the cervical and thoracic spine during an overhead reaching task involving a light weight transfer by the upper limb. Synchronized measurements of the three-dimensional spinal kinematics and electromyographic activities of cervical and thoracic spine were acquired in thirty individuals with chronic neck pain and thirty age- and gender-matched asymptomatic controls. Neck pain group showed a significantly decreased cervical velocity and acceleration while performing the task. They also displayed with a predominantly prolonged coactivation of cervical and thoracic muscles throughout the task cycle. The current findings highlighted the importance to examine differential kinematic variables of the spine which are associated with changes in the muscle recruitment in people with chronic neck pain. The results also provide an insight to the appropriate clinical intervention to promote the recovery of the functional disability commonly reported in patients with neck pain disorders.

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1. Introduction

Neck pain is a common health problem associated with significant functional disability (Côté et al., 2001, 2004; Hoving et al., 2004). Despite the fact that a significant proportion of patients improve, there are still a large number of patients who do not experience complete resolution of symptoms. Individuals who suffer chronic neck pain are often reported to have functional limitations in daily activities (Côté et al., 2008). Validated functional disability questionnaires like Northwick Park Disability Questionnaire (NPQ) and Neck Disability Index (NDI) are useful for assessing the impairments associated with neck symptoms (Leak et al., 1994; Ackelman and Lindgren, 2002). These questionnaires generally include items involving sedentary postures, overhead activity, carrying weight and driving as individuals with neck pain usually encountered difficulty in performing these tasks.

It has been suggested that deficits of optimal motor regulation and movement patterns might be a contributing factor to the development of chronic musculoskeletal dysfunction (Comerford

and Mottram, 2001; Hodges and Moseley, 2003). Therefore, clinical evaluation of the movement and motor control pattern of the neck for people may offer useful clinical information which may help understand the underlying sources of neck pain.

Studying kinematics with the use of three dimensional motion tracking device may offer better understanding about the deficiency of movement coordination. Most of the past research in neck pain individuals were focused on angular displacements of the cervical spine (Dallà Alba et al., 2001; De Hertogh et al., 2007; Jordan et al., 2004). However, differential kinematics (i.e. velocity and acceleration), which have been found to be significantly decreased in patient with cervical dystonia (De Beyl and Salvia, 2009; Gregori et al., 2008), have not been adequately examined in people with idiopathic neck pain.

Furthermore, studies of spinal and limb kinematics during functional tasks by three dimensional motion analysis system can help to reveal alterations in movement patterns and contribute to specific rehabilitation. Such functional approach has been successfully used to examine movement characteristics in patients suffering from neurological conditions (Mackey et al., 2006) and with low back pain (Shum et al., 2007; Wong and Lee, 2004). However, little was known on its potential applications for people with neck pain during functional activities.

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To further comprehend the motor control of human movements, surface electromyography has been widely used to evaluate muscle activity together with acquisition of kinematic data. Previous studies reported that altered muscle activation and motion control were commonly found in people with chronic neck pain (Falla, 2004; Falla and Farina, 2007). Deficits of the deep layer of cervical flexors in terms of reduction in strength and endurance capacity, has been found during cranio-cervical flexion movements (Jull et al., 2008), sustained muscle contractions (Falla et al., 2003), low load functional upper limb task (Falla et al., 2004a), and postural perturbations with rapid arm elevation (Falla et al., 2004b). Most of the previous EMG studies mainly examined the maximum amplitude of EMG activity with normalization method by either sub-maximal (SMVC) or maximal voluntary contraction (MVC); investigation of the muscle activation pattern throughout the whole movement cycle remains limited.

Most of the early studies examined the muscle activity during non-functional tasks. This approach limits the inference of the findings of muscle performance to daily functional task. Nederhand et al. (2000) and Falla et al. (2004a) examined the same functional task which involved a repetitive, unilateral arm dotting task performed by dominant side of upper limb elevated while the contralateral side rested motionless on a desk. Their results found that neck pain individuals demonstrated higher co-activation of the upper trapezius muscles on both sides compared to controls during the task and were also less able to relax the muscle upon completion of the task. However, the design of this experimental task only examined the upper trapezius and anterior scalenus with specific range of epochs of EMG activity. Events that may occur throughout the rest of the task remain unclear. It has been reported that upper trapezius activity levels varied significantly during raising and lowering phases of functional task involving arm elevation in healthy individuals (Ebaugh and Spinelli, 2010). To fill this knowledge gap, temporal analysis of EMG in detecting on-off muscle timing during the whole movement cycle may be a useful approach to study the recruitment patterns of the neck muscles during dynamic functional tasks. Beside upper trapezius and anterior scalenus, sternocleidomastoid muscle has also been intensively studied for its interaction with the deep cervical flexors during cranio-cervical flexion test and isometric voluntary contraction; and for its specificity of the feedforward activity during rapid arm elevation. However, this muscle has not been examined to a large extent under dynamic conditions, for example, its recruitment pattern and interplay with neck extensors during daily functional task.

Blummer et al. (2011) investigated the temporal characteristics of the cervical muscles while performing the same repetitive arm task developed by Nederhand et al. (2000). They found that different levels of muscle activity presented at specific time intervals during the task cycle. It is not yet possible to apply their findings directly to symptomatic individuals with their data obtained only from a small cohort of healthy participants at discrete time intervals of the task.

Better understanding of spinal movement pattern and motor control of the cervical and thoracic region during functional tasks would provide a foundation to enhance comprehensiveness of the physical examination and efficiency of therapeutic exercises for chronic neck pain conditions. To fill this knowledge gap, the purposes of this study were to assess the three-dimensional kinematics and muscle recruitment pattern of the cervical and thoracic spines in people with chronic neck pain while performing an overhead reaching task with a light weight transfer.

2. Materials and methods

2.1. Participants

Thirty participants with chronic neck pain and thirty age and gender matched asymptomatic individuals were recruited through the local community (Table 1). Ethic approvals of this study were obtained from the Roehampton University and The Hong Kong Polytechnic University. All participants signed the informed consent documents.

Symptomatic participants who had experienced neck pain which either lasted more than three months continuously or mostly presented over the last twelve months, were assigned as the Neck Pain group (NP). The severity of the neck condition had required medical care. Healthy participants who had no history of neck pain that required medical care over the last twelve months were allocated into the Asymptomatic (AS) group. Individuals who had any known neurological or orthopedic disorders, previous trauma or surgery to the brain or spine, sensory or vestibular deficits, bony abnormalities or deformities of the trunk or rheumatic disease, or temporomandibular joint dysfunction, were excluded.

All participants completed a general health questionnaire, Short Form-12 (SF-12) (Jenkinson and Layte, 1997). Pain intensity measured by the Numeric Pain Rating Scale 0–100 (NPRS 101) and functional limitations measured by the Northwick Park Disability Questionnaire (NPQ) of the neck pain participants were 37.67

Table 1
Descriptive statistics for the participants (mean (standard deviation)).

Variable	Asymptomatic (AS, n = 30) (21F & 9 M)	Neck pain (NP, n = 30) (22F & 8 M)	p-Value
Age (years)	35.10 (9.076)	38.33 (11.35)	0.228
	F 37.59 (11.23)	F 35.38 (9.52)	0.297
	M 40.38 (10.70)	M 38.44 (7.30)	0.142
Heights (m)			
Standing	1.64 (0.08)	1.63 (0.74)	0.496
Sitting	0.89 (0.04)	0.89 (0.04)	0.081
Weight (kg)	59.99 (10.78)	57.98 (11.47)	0.486
BMI (kg/m ²)	22.16 (3.24)	21.79 (3.13)	0.655
SF-12 score ^a			
PCS	54.10 (2.96)	44.46 (8.95)	<0.001*
MCS	53.903 (7.64)	44.51 (10.23)	<0.001*
NPQ (%)	NA	30.19 (12.22)	NA
NPRS (0–100)	NA	37.67 (18.74)	NA

BMI = Body Mass Index; MCS = Mental Component Score; NA = not applicable.

NPQ = Northwick Park Disability Questionnaire; NPRS = Numeric Pain Rating Scale.

PCS = Physical Component Score; SF-12 = Short Form 12 questionnaire.

* Indicates significant difference $p < 0.001$ between asymptomatic and neck pain participants.

^a Higher score indicates better general health.

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