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Neck posture during lifting and its effect on trunk muscle activation and lumbar spine posture

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ABSTRACT

Neck and head posture have been found to have a significant influence on the posture of the lower spine region during lifting and both an extended/upward gaze and a flexed/downward gaze have been hypothesized to lead to increased pain and/or overuse of the neck musculature. As a result, strength training recommendations have turned to the use of a retracted neck posture as being the safer posture to assume during lifting. This study examined trunk and neck muscle activity and lumbar spine posture in seven participants while performing moderate load lifts using a retracted neck posture (chin drawn in posteriorly; recently gaining popularity among coaches, trainers, and physical therapists to reduce neck pain during lifting, and freestyle neck posture (no instructions given). The retracted neck resulted in less lumbar spine flexion and increased lumbar erector spinae, external oblique, and sternocleidomastoid activity. The retracted posture also resulted in decreased activity in the thoracic erector spinae and dorsal neck musculature. The increased trunk and sternocleidomastoid activity and decreased spine flexion observed in the seven participants of this study when lifting with a retracted neck may have the potential to help lower the risk of spine pain/injury.

1. Introduction

Low back injury risk associated with lifting posture has been debated extensively with contradictory findings on hip and spine posture and the use of either a squat or stooped lift (extensive review by van Dieën et al., 1999; more recently Kingma et al., 2010; Kuijer et al., 2012; Wang et al., 2012). Neck and head position has also been contested, with the most common recommendation being a forward or slightly upward gaze, resulting in neck extension, during lifting exercises such as the squat (Donnelly et al., 2006). In particular, Donnelly et al. (2006) found that a forward or even upward gaze reduced trunk flexion during squatting, concluding that such a neck/head posture would be more protective of the back and was therefore recommended. Further, the opposite posture (a flexed neck) has been shown to result in a number of issues including increased risk of neck pain (Sim et al., 2006; Bokaee et al., 2016), potential overuse of the posterior neck muscles (Peolsson et al., 2014), decreased back extensor endurance (Dejanovic et al., 2015), and potentially compromised balance (Fairchild et al., 1993). However, an extended neck posture, despite being recommended by many (Donnelly et al., 2006; Myer et al., 2014), has also been shown to result in increased activity of the sternocleidomastoid muscles (Nimbarte et al., 2010). Increased muscle activation in the neck could result in high loading in the cervical spine region and an increase in incidence of neck pain (Griegel-Morris et al., 1992).

Due to the issues outlined above with the use of either a flexed or extended neck, the adoption of a retracted or "packed" neck posture has been thought to be more desirable and potentially protective during heavy lifting. Retraction of the neck results in upper cervical flexion combined with lower cervical extension (Ordway et al., 1999), and also leads to extension of the upper thoracic vertebrae (Edmondston and Singer, 1997). Further, neck retraction has been shown to decrease radicular pain by decompressing the cervical nerve roots (Abdulwahab and Sabbahi, 2000).

The retracted neck posture has recently been adopted by coaches, trainers and physical therapists; however this has been generally based on anecdotal rather than empirical evidence. Therefore, it would be beneficial to have evidence-based

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recommendations regarding neck posture during lifting to improve spine safety. The purpose of this study was to compare trunk and neck muscle activation and lumbar spine posture during stoop lifting with two different neck positions; retracted and freestyle.

2. Methods

2.1. Participant recruitment

Seven participants (3 male and 4 female; all right hand dominant) sampled from a university population with no history of back pain in the last 12 months were recruited (average (SD) age of 22.7 years (2.6); mass of 70.2 kg (14.6); height of 1.75 m (0.11)). Each participant was required to review and sign consent to the study protocol approved by the University research ethics board.

2.2. Electromyography instrumentation and normalization

Prior to electromyography (EMG) electrode placement, skin was prepped, if necessary, by shaving any hair on the skin overlying the muscle belly and by cleansing the skin with 70% isopropyl-rubbing alcohol. Pairs of disposable Ag-AgCl electrodes (BlueSensor, Ambu, Denmark) were then placed over the following muscles uniaxially (right side only): thoracic erector spinae (TES), lumbar erector spine (LES), external oblique (EO), and internal oblique (IO), and bilaterally over sternocleidomastoid (SCM - sternal region of muscle belly approximately midway between the mastoid process and manubrium) and the dorsal neck muscles (splenius capitis and upper trapezius - 5 cm bilateral of the cervical spine at the level of approximately C3). Electrode placements for trunk muscles were obtained from McGill et al., 1996 and the neck muscles from Falla et al. (2002).

Following electrode placement, participants performed maximum voluntary contractions (MVCs) for each muscle for normalization purposes. For the TES and LES muscles, a maximal Biering-Sorensen back extension was performed with the participant's torso hanging off the end of a bench. With the lower body and legs secured to the bench, participants maximally and isometrically extended against resistance provided by the researcher for approximately 5 s. The EO and IO MVCs were obtained by having participants perform a modified sit-up position while isometrically flexing and twisting against resistance by the researcher. Last, the SCM and dorsal neck muscle MVCs were obtained by having participants isometrically extend, laterally bend and twist their neck to the left and right against resistance provided by the researcher. For each group of muscles, 2–3 MVCs were performed to ensure maximal voluntary activation was achieved. At least two minutes of rest was given in between each MVC trial in order to not induce muscular fatigue. Following EMG signal processing (see section 2.6), the maximum value from the MVC with the highest recorded signal was used to normalize all subsequent EMG data.

2.3. Motion capture instrumentation

Following MVCs, participants were equipped with four electromagnetic motion sensors (Liberty, Polhemus, Vermont, USA) placed on the posterior head (attached to a headband), C7, T12 and L5 spinous processes. Sensors were adhered to the skin over the corresponding spinous processes via double-sided tape. The angle between the head and C7 markers defined the cervical neck posture and the angle between the T12 and L5 marker defined the lumbar spine posture. A five-second upright standing trial was used to define the neutral spine posture. Motion data were sampled at 32Hz.

2.4. Lifting protocol

Participants performed 16 lifts with a 10 kg mass. For eight of these lifts, participants were instructed to assume a "retracted" neck posture, or draw the chin posteriorly towards the cervical spine for the entire lift, while the remaining eight were considered freestyle (no instructions in order to capture how each individual naturally lifts) (Fig. 1). Lifts were performed in groups of four using the same style; however order of these groups were randomly assigned. For each lift, participants were instructed to start in a neutral upright standing posture, assume the neck posture for the given trial (retracted or freestyle) then flex forward to pick up the 10 kg mass which was pre-set to be located at the height of the participant's tibia, specifically at the midpoint between the proximal and distal end of the tibia. Participants then returned to upright standing while still assuming the same neck posture, paused for approximately 1–2 s, then flexed forward to return the mass to the original starting position. Each full lift and lower trial took approximately 15 s. One minute rest was given in between each lift trial. A stoop lift, rather than squat lift, was chosen because it is typically considered a more risky lifting posture. Further, a more neutral neck posture often accompanies the squat lifting posture, and differences may not have been as apparent if a squat posture were examined.

2.5. Perceived exertion and discomfort and exit survey

Following each block of four lifts, participants were asked to rate their perceived exertion using a 10 point Borg scale as well as their discomfort (lower back, upper back, shoulders, neck, overall) using a 100 mm visual analogue scale. The discomfort scale had the following anchors: 0 – no discomfort; 100 – worst discomfort imaginable. Following the study, participants were asked to complete an exit survey which addressed questions about their lifting style preference (Table 1).

2.6. Data analysis

EMG data were bandpass filtered from 10 to 1000 Hz, amplified (Bortec, Calgary, Alberta) and sampled at 2048 Hz. Raw EMG data were subsequently full-wave rectified and single-pass filtered using a second-order Butterworth filter with a low-pass cut off of 2.5 Hz to create a linear envelope (Brereton and McGill, 1998). The linear enveloped data for the lifting trials were further normalized to each MVC performed. Motion data were dual low-pass filtered with a 6Hz cut-off. The peak activation for each of eight muscles (%MVC) and the peak lumbar spine and cervical spine sagittal plane motion (degrees) were determined for each complete trial (lift and lower combined). Perceived discomfort was determined by measuring to the nearest mm on the visual analogue scales.

2.7. Statistical analysis

One-way repeated measures analysis of variance (ANOVA) tests were conducted to determine the effect of neck posture on 1) peak muscle activation, 2) peak lumbar spine posture, and 3) perceived exertion and discomfort. An alpha level of 0.05 was set as significant.

3. Results

3.1. Cervical posture during freestyle and retracted lifts

The peak sagittal plane cervical posture during the freestyle lifts, on average, ranged from 15.4 degrees flexion to 26.9 degrees