

KINEMATIC ANALYSIS OF TRUNK MOTIONS DURING FREESTYLE LIFTS

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INTRODUCTION

In recent years trunk angular motion characteristics have been used for the quantification and classification of various low back disorders with some success (Marras et al., 1995). It was felt by the authors of this paper that the trunk motion characteristics could be used to gain a better understating of lifting technique. An earlier communication presented the use of a classical cluster analysis performed on a series of trunk motion profiles in order to group individuals with similar motions during their lift (Albert et al., 2000). The uniqueness of this methodology was that it identified individuals based on eleven separate curves rather than one or two discrete variables.

This paper presents the trunk motion characteristics that separated the industrial population of manual material handlers into separate lifting technique groups.

METHODS

The freestyle lifting techniques of 108 male experienced manual material handlers performing sagittal lifts of a moderate load (15kg) were tracked using the FASTRAK™ motion system. In order to define back motion, electromagnetic sensors were placed on the L1 and T1 vertebrae and on the L5/S1 intervertebral space. A sensor on the wrist tracked the box and defined arm motion. Data collection and subsequent computations produced eleven kinematic

curves of interest that explained the motion of the upper body and were chosen to describe the technique of the experienced lifter. All motion curves were normalized to 50 points from the start to the end of the lift and were then averaged, at each time point, over the five trials within each subject.

Datasets for those variables were grouped according to their descriptive purpose and the component curves were strung end to end within a single row representing a subject for purposes of cluster analysis. A separate cluster analysis was performed on each dataset of merged curves pertaining to posture profiles (sacrum height, trunk angle, wrist-to-sacrum distance), trunk flexion profiles (T1, L1 and L5/S1 flexion velocity), and trunk segment bend profiles (thoracic and lumbo-sacral bend, and their corresponding velocities).

The clustering exercise resulting in the subjects being divided into three groupings based on their division in each analysis. The 29 subjects who were consistently assigned to group 1 were considered the 'Squat Posture Group' as their average trunk flexion was 48 degrees at the start of the lift. The 33 subjects who were consistently assigned to group 2 were named the 'Squat Posture Group' since their corresponding trunk flexion was 91 degrees. The remaining 42 individuals were not consistent in their grouping. The following discussion focuses on trunk motions of the first two groupings only. Discussion of the third group will be presented in a future communication.

RESULTS and DISCUSSION

Trunk Flexion. The trunk flexion / extension velocities determined at T1, L1 and L5/S1 were all larger for 'Stoop Posture' Group. This group may have relied on the trunk momentum to overcome the inertia of the box to begin the lift. Starting from a flexed position, the trunk began to extend rapidly for the first 40% of the lift. This rapid extension served to lift the box, as there was only a slight increase in sacrum height during this period. The extension of the sacral (pelvic) segment led the motion of the trunk. The lumbar and thoracic segments lagged slightly behind, and then extended almost simultaneously. It is thought that initiation of motion by posterior pelvis rotation delays lumbar extension thereby shortening the moment arm of the external load resulting in less erector spinae stress (Farfan, 1978).

The 'Squat Posture' Group flexed their trunk slightly at the start of the lift indicated by the pronounced T1, L1 and L5/S1 flexion velocity during the first 20% of the lift. This may be the result of the sequence of movements used to lift the box from a squat position. Scholz et al. (1995) have indicated that a coordinated pattern whereby knee extension leads trunk extension exists in lifts initiated in squat and freestyle lifting postures.

Using the vertical motion of the sacrum as a proxy for knee flexion allowed for an evaluation of knee-trunk coordination. From the squatting position, the knees and pelvis extended well in advance of the trunk. Within the first 20% of the lift the knees have extended 0.20 m with little to no movement in the trunk angle. This would cause the trunk to flex forward under the weight of the box and in reaction to the body's upward momentum.

Thoracic and Lumbar Bend. The bend angles and their corresponding velocities also reflected the lower trunk activity in the 'Squat Posture' Group. There was only a slight thoracic bend throughout the entire lift and while the lumbar segment began in slight kyphosis it maintained a lordotic posture for most of the lift. As a result, the velocities of the thoracic and lumbar bend were slower and peak velocity occurred later in the lift. Lumbar kyphosis has been thought to be advantageous in reducing stress at the apophyseal joints, reducing compressive stress and providing compressive strength to the spine (Adams and Hutton, 1985). The 'Stoop Posture' Group displayed a larger range of motion in both the thoracic and lumbar regions. The lumbar bend was in kyphosis for the first half of the lift before attaining a lordotic posture. The velocities of 'Stoop Posture' Group bend angles were higher than 'Squat Posture' Group reflective of the quicker trunk motion used to lift the box.

CONCLUSIONS

Although it has been suggested that a single correct lifting technique does not exist, the results of the clustering approach reveal that there is consistency with respect to the trunk motions selected. It is also interesting to note that the different trunk motions and corresponding velocities, which defined the lift technique, resulted in similar box trajectories. Peak lumbosacral compression values were found to be within safe limits (according to NIOSH) irrespective of lift technique.

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