Relationships Between Trunk Movement Patterns During Lifting Tasks Compared With Unloaded Extension From a Flexed Posture

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Abstract

Objectives: The purpose of this study was to investigate between movement patterns of trunk extension from full unloaded flexion and lifting techniques, which could provide valuable information to physical therapists, doctors of chiropractic, and other manual therapists.

Methods: A within-participant study design was used. Whole-body kinematic and kinetic data during lifting and full trunk flexion were collected from 16 healthy male participants using a 3-dimensional motion analysis system (Vicon Motion Systems). To evaluate the relationships of joint movement between lifting and full trunk flexion, Pearson correlation coefficients were calculated.

Results: There was no significant correlation between the amount of change in the lumbar extension angle during the first half of the lifting trials and lumbar movement during unloaded trunk flexion and extension. However, the amount of change in the lumbar extension angle during lifting was significantly negatively correlated with hip movement during unloaded trunk flexion and extension ($P < .05$).

Conclusions: The findings that the maximum hip flexion angle during full trunk flexion had a greater influence on kinematics of lumbar–hip complex during lifting provides new insight into human movement during lifting. All study participants were healthy men; thus, findings are limited to this group. (J Manipulative Physiol Ther 2018;41:189-198)

Key Indexing Terms: *Low Back Pain; Physical Therapist Assistants; Spine; Lifting*

Introduction

With a lifetime prevalence of 38.9%, low back pain (LBP) affects a substantial proportion of individuals, and in particular, during their productive years.[1,2] In the United States, medical claims related to back injuries constituted 19% of all workers' compensation claims but were disproportionally responsible for 41% of the total injury costs.[3] Low back pain is a prevalent public health concern worldwide that not only affects individuals but also exerts a global socioeconomic burden. According to an announcement by the Japanese Ministry of Health, Labor and Welfare in 2013, LBP accounted for 60% of industrial injuries, with LBP occurring most often during manual handling activities.[4] As described earlier, it is well established that the activity of lifting is a primary risk factor for LBP.[5]

Compression force and shear force are the 2 main mechanical stresses applied to the lumbar region during lifting.[6-9] An increased compression force causes higher stress to intervertebral discs, which can result in the degeneration of intervertebral discs and/or lumbar disc herniation.[7,10] On the other hand, a shear force is applied to the intervertebral joint plane. In addition, large range of motion of the intervertebral joint causes higher stress to the intervertebral joints.[11] Therefore, increasing not only shear force but also the lumbar extension movement with high shear force can increase the stress applied to the intervertebral joints, thereby increasing the risk of intervertebral joint degeneration.[12,13] Thus, increased lumbar extension movement during lifting can increase the risk of LBP. On the basis of this information, when discussing the stress applied to the intervertebral joints, we should consider

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Table 1. *Participant Characteristics*

Variables	Mean (SD)
Age, y	24.5 (2.2)
Height, m	1.73 (0.1)
Mass, kg	66.4 (7.0)
BMI, kg/m^2	22.2 (1.7)

BMI, body mass index; *SD,* standard deviation.

not only the shear force but also the degree of lumbar extension movement during lifting. This association suggests that evaluating the lumbar movement patterns of individuals engaged in daily lifting tasks has clinical significance.

However, if patients with LBP perform lifting tasks in the clinic to evaluate their movement patterns, the lifting tasks may either cause or exacerbate LBP. Therefore, physical therapists and chiropractors usually evaluate patient lumbar-hip movement patterns during sagittal trunk rotation in the clinic, with some previous reports investigating the kinematics of the lumbar–pelvic–hip complex during sagittal trunk rotation task and/or lifting tasks.[14-18]

In 2015, Alqhtani et al[18] reported that sagittal kinematics of the hip and lumbar spine during trunk flexion are different from those observed during other functional tasks and clinicians should not be overdependent on the interpretation of flexion range of motion within the clinic to determine the degree of impairment. In their report, the lifting task consisted of stoop lifting, and the range of motions and velocities during particular phases were not analyzed. However, previous researchers reported that stoop lifting causes higher shear force on the lower back,[19,20] and lumbar movement during the initial phase of extension is associated with LBP.[21] The relationship between lifting techniques used in clinic and trunk extension from full unloaded flexion remains unclear.

Therefore, investigating the relationships of lumbar–hip movement patterns between trunk extension from full unloaded flexion and lifting tasks during particular phases may provide fruitful findings to aid clinical reasoning and judgement. The purpose of this study was to investigate between movement patterns of trunk extension from full unloaded flexion and lifting techniques, which could provide valuable information to physical therapists, doctors of chiropractic, and other manual therapists. We hypothesized that lumbar–hip movement patterns were interrelated during trunk extension from full unloaded flexion and the phases of lifting tasks.

Methods

Participants

Sixteen healthy male participants were recruited (Table 1). Participants were excluded if they reported any current musculoskeletal injury or pain, previous lower extremity or

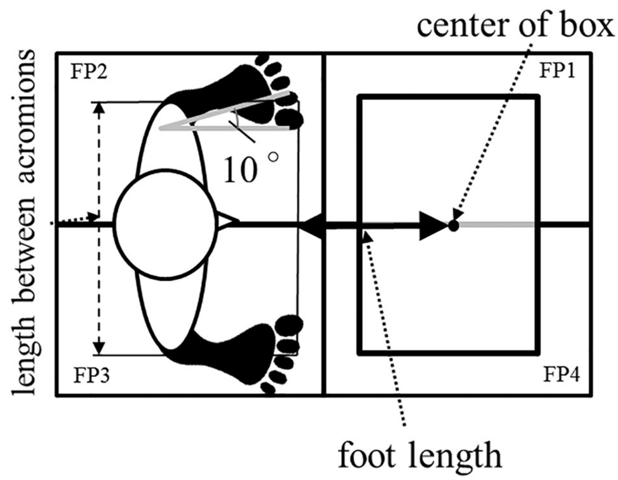

Fig 1. *Foot and box placement on force plates.* FP, *force plates.*

lumbar surgery, a history of LBP, or a neuromuscular disease that could affect their ability to lift. Before participation, the goal of the study was explained to all participants, and oral and written consent was obtained from each participant. The study protocol was approved by the Ethics Committee of Hiroshima University Graduate School of Health Sciences prior to the study (No. 1507).

Data Collection

For assessment of movement patterns during lifting and unloaded trunk flexion and extension, a 3-dimensional motion analysis system (Vicon Motion Systems, Oxford, United Kingdom) equipped with 6 cameras recording at a 100-Hz sampling rate was used to capture the positions of 48 retroreflective markers attached to anatomic landmarks.

Participants were instructed to lift a box containing a 7.5-kg weight with their feet apart at the distance between both acromions from half the height of their shank to half the height of their thigh at a comfortable speed. The distance between the center of the box and the toes were set as foot length, and foot progression angle was set at a 10° toe out (Fig 1). The participants were instructed to flex their knees at 4 different knee angle magnitudes (0°, 30°, 60°, and 90°) using feedback when they reached the box, and then perform 5 lifting trials under each conditions in a randomized order (Fig 2).

Thigh and shank marker position data were streamed from the Vicon Nexus Version 2.1.1 to MatLab 2014a (MathWorks, Natick, Massachusetts) to calculate the knee flexion angle (KFA). Then KFA was displayed as a blue arrow on a screen located at a distance of a single body height from the tip of the participant's feet. The 12 o'clock direction indicated 0°, and clockwise rotation indicated an