ACC-RAC NBCE AWARD-WINNING PAPER

Procedure Selection and Patient Positioning Influence Spine Kinematics During High-Velocity, Low-Amplitude Spinal Manipulation Applied to the Low Back

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Abstract

Objectives: This investigation compared indirect 3-dimensional angular kinematics (position, velocity, and acceleration) of the lumbar spine for 2 different high-velocity, low-amplitude (HVLA) spinal manipulation procedures (lumbar spinous pull or push), and altered initial patient lower limb posture.

Methods: Twenty-four participants underwent 6 HVLA procedures directed toward the presumed L4 vertebra, reflecting each combination of 2 variants of a spinal manipulation application technique (spinous pull and push) and 3 initial hip flexion angles (0°, 45°, and 90°) applied using a right lateral recumbent patient position. All contact forces and moments between the patient and the external environment, as well as 3-dimensional kinematics of the patient's pelvis and thorax, were recorded. Lumbar spine angular positions, velocities, and accelerations were analyzed within the preload and impulse stages of each HVLA trial.

Results: Lumbar spine left axial rotation was greater for the pull HVLA. The pull HVLA also generated a greater maximum (leftward) and lower minimum (rightward) axial rotation velocity and deceleration and greater leftward and rightward lateral bend velocities, acceleration, and deceleration components. Not flexing the hip produced the greatest amount of extension, as well as the lowest axial rotation and maximum axial rotation acceleration during the impulse.

Conclusions: This investigation provides basic kinematic information for clinicians to understand the similarities and differences between 2 HVLA side-lying manipulations in the lumbar spine. Use of these findings and novel technology can drive future research initiatives that can both affect clinical decision making and influence teaching environments surrounding spinal manipulative therapy skill acquisition. (J Manipulative Physiol Ther 2017;xx:1-9)

Key Indexing Terms: *Musculoskeletal Manipulations; Lumbar Region; Biomechanical Phenomena; Low Back Pain; Chiropractic*

Introduction

Before delivering treatment in the form of a high-velocity, low-amplitude (HVLA) spinal manipulation, trained manual therapists must decide on several application parameters related to the patient, provider, and procedure.[1] The net result of these decisions manifests as a set of procedures that theoretically provide different biomechanical and clinical effects to the patient.[2,3] Findings from randomized clinical trials in humans and lab-based animal studies both suggest that HVLA application parameters can drive clinical and neurophysiological responses[4-7]; however, few in vivo efforts[8] have attempted to quantify the biomechanical differences, if they exist, between procedures directed to the same site.

Indirect kinematic analyses are particularly useful to describe differences between human motions and can be applied to the in vivo quantitative evaluation of biomechanical differences and similarities between HVLA spinal manipulation procedures. Specifically, 3-dimensional angular kinematic analysis has been performed and reported

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previously for cervical HVLA spinal manipulation,[9,10] but this has not yet been done for spinal manipulation applied to the lumbar spine. Thus, the purpose of this study was to describe and compare 3-dimensional angular kinematics (position, velocity, and acceleration) of the lumbar spine for 2 different HVLA spinal manipulation procedures (diversified technique with either a lumbar spinous pull or push) and altered initial patient lower limb posture. It was hypothesized that indirect kinematics of the patient's lumbar spine would be influenced by both spinal manipulation application procedure and initial hip flexion angle.

Methods

Participants

Twenty-four participants were recruited for this investigation (12 men, 12 women, 25.0 ± 2.5 years old, 1.81 ± 0.04 m, 77.5 ± 8.0 kg). Before data collection, all participants read and signed an informed consent document outlining the experimental protocols that were approved by the institution's research ethics board (Approval #1404A01). All participants were required to have been asymptomatic in the low back region for 3 months before data collection and have no history of significant spinal pathologic conditions (eg, fracture, surgery, spinal cord injury, dislocation, infection, neoplasm, or systemic disease).[11]

Instrumentation

A customized treatment table with an embedded force plate was used to record the contact forces and moments between the patient's thorax and the table surface (OR6-7, AMTI Inc., Watertown, MA).[11] Two 6-degree-of-freedom load cells (Mini45, ATI Industrial Automation Inc., Apex, NC) were used to measure applied forces and moments between each of the clinician's hands and the patient.[12] Custom plastic grips, fabricated using a 3-dimensional printer (Airwolf3D HDL, Airwolf 3D, Costa Mesa, CA), were mounted to each load cell to mimic clinical hand contacts and ensure that the clinician's hands interacted only with the participant to reduce the possibility of load sharing. Load cells were attached to the skin using double-sided tape. All analog data from the force plate and load cells were recorded at a rate of 1500 Hz (Optotrak Data Acquisition Unit, Northern Digital Inc., Waterloo, ON, Canada).

Three active infrared light–emitting diodes (IREDs) were adhered to plastic flags that extended from each load cell. Two additional sets of 3 IREDs were affixed to plastic plates that were held in place by belts strapped around the participant's thorax (at the level of the T9 spinous process) and pelvis. The fixed geometric arrangements for each set of 3 markers defined separate rigid bodies, and the movement of each rigid body represented the angular orientations of the segments or load cells to which they were attached. Three-dimensional coordinates of each IRED were continuously monitored at a rate of 150 Hz using 2 banks of optoelectronic cameras (Optotrak Certus, Northern Digital Inc., Waterloo, ON, Canada).

Four points were digitized on each load cell before data collection using a calibrated probe. These points identified the location and orientation of the load cells within the lab's global coordinate system. Anatomic landmarks representing the participant's greater trochanters, iliac crests, anterior superior iliac spines, L5 spinous process, acromion processes, suprasternal notch, xiphoid process, and T12 spinous process were identified through manual palpation and were also digitized before data collection. Digitization of the anatomic landmarks was performed with the participant standing in an upright and anatomically neutral posture. Anatomic landmarks were used to construct anatomic frames of reference for the participant's pelvis and thorax. The 3-dimensional coordinates for the load cell and anatomic landmarks were virtually monitored throughout all experimental trials by assuming a fixed spatial relationship between the landmarks and the rigid bodies that measured the positions and orientations of their parent segment or load cell. Static 3-dimensional coordinates of the force plate's 4 corners were also digitized, along with the location of a reference point on the treatment table's surface. These coordinates were used to transform forces and moments from the force plate's local coordinate system into the lab's global coordinate system and to locate the force plate within the lab. The time-varying 3-dimensional coordinates of each digitized point were also obtained at a rate of 150 Hz and synchronized with the data from the IREDs and the analog data obtained from the load cells and force plate.

Protocol

After instrumentation and calibration, participants were positioned in a right side-lying posture with arms bent at the elbow and crossed in front of them, as previously published by our group (Fig 1).[13] Each participant underwent a total of 6 HVLA procedures directed toward the fourth lumbar vertebra (L4) and were delivered by a single experienced chiropractor with 5 years of experience. The number of HVLA manipulations reflected each combination of 2 variants of a diversified technique (lumbar spinous pull, lumbar spinous push) and 3 initial flexion angles (0°, 45°, or 90°) for the participant's left hip. Common to both HVLA procedures was the initial positioning of the patient in right lateral recumbent position. At the same time, the clinician used his left hand to apply an anterior-to-posterior directed force to the anterior aspect of the patient's left shoulder. The pelvis position was controlled by pressure applied via the clinician's right forearm through the