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EFFECTS OF LUMBO-PELVIC RHYTHM ON TRUNK MUSCLE FORCES AND DISC LOAD DURING FORWARD FLEXION: COMBINED MUSCULOSKELETAL AND FINITE ELEMENT MODELING

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Summary: Frequent forward flexion in daily life involves flexion of the lumbar spine and rotation of the pelvis. The total rotation of the lumbar spine and pelvis is referred to as lumbo-pelvic coordination or rhythm. Literature on spinal kinematics during forward flexion includes a wide range of in-vivo lumbar spine- and lumbo-pelvic rhythm data. It was reported that lumbo-pelvic coordination during forward flexion differs from the backward extension and varies with rotation angle. On the other hand, musculoskeletal models of the thorax routinely use spinal rhythm to predict muscle forces and joint loads in the spine. Thus, understanding the effects of lumbo-pelvic rhythm on spinal load prediction is of prime importance. A recent study found that the effects of lumbar spine rhythms and intra-abdominal pressure on the muscle forces and spinal load in the lumbar disc L4-L5 increase with large flexion angles. This study aims to quantify the effects of various lumbo-plevic ratios on muscle forces and disc loads using a musculoskeletal model of the thorax combined with a nonlinear 3D Finite Element (FE) model of the ligamentous lumbosacral spine L5-S1.This novel global/local combined modeling technique has been recently validated in our previous study. The musculoskeletal model was developed using standard male anthropometry (height: 186cm, weight: 70 kg), and was subjected to 60 deg forward flexion using three different lumbo-pelvic rotation ratios of 1.5, 3, and ∞ (pelvis fixed). The lumbo-pelvic rotation ratio was defined as the ratio of lumbar rotation to pelvic rotation. The muscle and joint reaction forces predicted by the musculoskeletal model, in addition to boundary conditions, were then applied to the FE model. Our results revealed that pelvic rotation during flexion with a lumbo-pelvic ratio of 1.5 decreased local muscle forces by 32% and increased global muscle forces by 53% for angles between 0 and 50°. The muscle forces were decreased by 32% after 50 deg relative to flexion with a fixed pelvis. The lumbo pelvic ratio of 1.5 also reduced the intradiscal pressure (IDP) in the intervertebral discs at levels L1-L3 by about 12% but increased it by 52% at level L4-L5.