A dynamic biomechanical evaluation of asymmetric lifting using the AnyBody commercial software: A pilot study

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Abstract:

The AnyBody Modeling System is, by far, the most detailed commercially available human musculoskeletal modeling software. It contains a lumbar spine model consisting of seven rigid segments with 18 degrees-of-freedom and 154 muscles. The model is based on inverse dynamics, and the muscle redundancy problem is solved by optimization method. AnyBody has been utilized to validate internal muscle and joint forces, but none of the studies investigated the effect of asymmetry in dynamic lifting. The principal objective of this study is to implement AnyBody to analyze internal torso loading in asymmetric and dynamic lifting tasks.

A six-camera Optitrack motion capture system recorded the time dependent motion data from 34 light reflecting body markers during the lifting tasks. The lifting tasks consisted of lifting a 13.6kg weight from knuckle height, with the horizontal distance of 53 cm from the center of the weight to the lumbar spine. The lifting task was carried out in combinations of three asymmetry levels (0°, 30° and 60°) randomly, and three trials were performed for each asymmetry. An AMTI force platform was employed to capture ground reaction forces. AnyBody computed the muscle and spinal forces utilizing the motion capture data files. The recorded ground reaction force was used to validate the biomechanical analysis.

Erector spinae (ES), the main trunk extensor, generated 1290N to 1590N forces. When lifting origin became more asymmetric toward the right, the trunk was rotated and laterally flexed more toward the right. As a result of this, the right external oblique (REO) was 85.1% and 111.9% more active for 30° and 60° lifts, respectively, compared to that of the sagittal lift. Right internal oblique (RIO) exhibited complementary activation, and was 23.5% and 35.9% less active for 30° and 60° lifts, respectively, as compared to that of the sagittal lift. Left external oblique (LEO) was insignificantly

activated and generated force less than 50N. Left internal oblique (LIO) generated 119N to 183N forces during the lifting tasks, but no significant difference noted between trials.

Compared to ES, oblique muscles with larger moment arms can support an external moment with less joint force at L5/S1. As a result of this, L5/S1 maximum compression force of 3690N at 0° was reduced by 14% and by 15% for 30° and 60° asymmetry, respectively. The A/P shear force of 675N at 0° was reduced by 16% and 23% for 30° and 60° asymmetry, respectively.

For an identical lifting task, the average of the maximum L5/S1 compression force derived from 10 subjects by Marras et al.'s EMG assisted model (1998) was 3600N for sagittal lifting, which is comparable to the 3690N output from AnyBody. But, contrary to the results of the previous study, the compression force was reduced as the lifts became more asymmetric. For increasing asymmetry of lifts, the pattern of changes of the two spinal shear forces were similar for the two models, but AnyBody predicted significantly small shear forces.

Asymmetric manual lifting has been identified as an occupational risk factor for lower back disorder (LBD). This study contributes to the design and evaluation of asymmetric lifting tasks.