Research on the biomechanics of lumbar muscles based on musculoskeletal model

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Abstract

Musculoskeletal Disorders are common in many industrialized countries, while lower back pain (LBP) is the most common one. Despite the pathogenesis of LBP is complex, it has been posited to originate mostly from biomechanical-based deficits.

LifeMOD, Anybody, ANSYS are mainly computer software for human muscle force research. The advantage of LifeMOD is it's best human-interactive program, whereas the control of muscle mechanics properties is inaccuracy. Anybody is often used in industrial laboratories, the limitation is the imprecise simulation of motion. ANSYS is based on the classical finite elements analysis, however, complicacy of human body model and muscle's material property makes it infeasible to analyze, moreover, ANSYS programs are conducted by applying static pressure which is unreasonable when simulating movement.

Opensim is an open-source software based on C++ and JAVA to create musculoskeletal model and analyze dynamic simulation. It can be used to simulate human movement dynamically, thereby studying kinematics characteristic of joints, property of muscle-tendon, muscle force and joints force is feasible.

Christophy et al. set up a new musculoskeletal model for the lumbar spine with many anatomical data. This model features a rigid pelvis and sacrum, the five lumbar vertebrae, and a rigid torso consisting of a lumped thoracic spine and ribcage, additionally, the eight main muscle groups of the lumbar spine were incorporated using 238 muscle fascicles with prescriptions for the parameters in Thelen-type.

On this basis, incorporate 170cm tall standard limb model built by KR.S et al(Stanford University) to complete and modify Christophy(2012) lumbar spine model. The Inverse Dynamics(ID) Tool in Opensim will determine the generalized forces(net forces and torques) that cause a particular motion, and its results can be used to infer how muscles are actuated to generate that motion. While Static Optimization is an extension of ID Tool, it can distribute individual muscle forces based on performance criteria, like minimizing the sum of squared muscle forces.

Comparing with existing intervertebral pressure under different poses by lots of experiments, the precision of estimating joints force by this model can be verified. Furthermore, electromyography (EMG) has been certified a relationship with muscle force, comparing with the available measuring data of EMG so that the accuracy of muscle force calculated by Opensim is verified.

Existing motion files can be improved to gain the muscle's mechanical data under different poses and movements.

In this research, a reasonable and well-organized human lumbar musculoskeletal model can be set up on Opensim platform. Muscle forces distribution will be given in different motions and positions, aiming to contribute to a better understand of muscle's cooperation.

Keywords: Lumbar muscle, Opensim, Musculoskeletal model, Inverse dynamics

References

[1] 孟祥杰. 基于肌肉骨骼系统生物力学载荷的驾驶人腰部舒适性研究[D]. 清华大学， 2015.

[2] Christophy M, Senan N A F. A Musculoskeletal Model for the Lumbar Spine. Biomechanics and Modeling in Mechanobiology, 2012, 11: 19-34.
[3] Seth A, Sherman M, Reinbolt J A, Delp S L. OpenSim: a musculoskeletal modeling and simulation framework for in silico investigations and exchange. Procedia IUTAM,2011,2:212-232.
[4] Miguel Christophy,Maurice Curtin,Nur Adila Faruk Senan,Jeffrey C. Lotz,Oliver M. O'Reilly: On the modeling of the intervertebral joint in multibody models for the spine[J]. Multibody System Dynamics . 2013 (4).