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Stochastic biomechanical modeling is a biomechanical modeling paradigm to determine probability of random outcomes of human motion. A stochastic biomechanical model generally contains (1) a deterministic model of injury measure as function of a domain of possible inputs, (2) algorithms to generate inputs randomly from the domain using a certain specified probability distribution, (3) repeated deterministic computations using the random inputs, and (4) aggregation of the results of repeated computations into the final result. Stochastic biomechanical modeling is an ideal tool for determining the risk and risk factors of acute musculoskeletal injuries. Compared to traditional epidemiological methods, stochastic biomechanical modeling allows investigators to estimate the risk of a given injury through simple biomechanical testing without lengthy follow-ups and before injury actually occurs. Also, stochastic biomechanical modeling allows investigators to establish biomechanical relationships between risk and risk factors of the injury and quantify the effects of risk factors on the risk. These advantages make the stochastic biomechanical modeling an effective, efficient, and inexpensive method for research on acute musculoskeletal injuries.

Although the concepts of this method have been well established and applied in studies on a variety of musculoskeletal system injuries, this method has not been well recognized and applied in research on acute musculoskeletal system injuries. Lack of biomechanical properties of musculoskeletal structures and the quantitative relationships between loading of a given musculoskeletal structure and external loading is a primary limitation to the broad applications of stochastic biomechanical modeling approach in research on acute musculoskeletal injuries.

Recommendations

1. Establish the mechanical and mathematical relationship between injury measure of a given musculoskeletal structure and biomechanical variables related to the prevention and rehabilitation of the acute injury of the given musculoskeletal structure through in vitro and in vivo studies. This is critical for development of stochastic biomechanical models of acute musculoskeletal injuries. For example, the effects of anterior shear force at the knee, knee valgus/varus and internal/external rotation moments, and loading rate on the anterior cruciate ligament (ACL) loading need to be quantitatively described to develop a stochastic biomechanical model of ACL injury.

2. Establish stochastic biomechanical models to estimate the probabilities of selected musculoskeletal injuries and identify the risk factors of these injuries.

3. Validate stochastic biomechanical models by validating the estimated probability of the injury and the estimated muscle and ligament forces through in vitro and in vivo studies. A valid estimate of muscle forces may assist in establishing the validity of a stochastic biomechanical model of an acute musculoskeletal injury. For example, in a stochastic biomechanical model of ACL injury, for a given combination of the hamstring and gastrocnemius muscle forces, the validity of estimated patella tendon force is critical for a valid estimate of ACL loading.

4. Encourage applications of stochastic biomechanical modeling approach in research. The advantage and nature of stochastic biomechanical modeling should be fully recognized. The limitation of the approach should be viewed objectively and realistically.