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【Keynote lecture IV】

Segment-interaction and its relevance to muscle injury during sprint running

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In athletics, superior sprint running performance is often attributed, at least in part, to the athlete having powerful musculature that can make lower extremity move quickly during swing phase and withstand the maximum ground reaction force in stance phase. Therefore, the study about the function of torque on the hip and knee joint can help us to understand the movement control and to get insights into the mechanisms of lower extremity muscles injury during swing and contact phase. The intersegmental dynamics was used to study multi- relationship of the active muscle torques (MUS), the passive motion-dependent torques (MDT), ground reaction torque (GRT), gravitational torque (GRA) and net joint torque (NET) during the swing phase and the stance phase, and from this to quantify the contribution of each torque to the joint motion of lower extremity.

During swing phase, the MUS functioned to counterbalance the effect of the MDT, while the GRT and other kind torques were smaller than MUS and MDT, and have no significant contribution to the joint motion. The maximum MUS and MDT of knee (249.32 ± 38.81 Nm, 194.01 ± 30.90 Nm) and hip (650.81 ± 101.06 Nm, 410.80 ± 78.67 Nm) joint appeared in the late swing phase. The torque due to leg angular acceleration on the knee and hip joint was the main inertial torque in the MDT during swing phase. During the late swing phase, the MUS counteract the MDT and make the knee joint flex at the knee joint,

meanwhile, the MUS counteract the MDT and make the hip joint extend at the hip joint. Based on the relationship between force (torque) and (angular) acceleration, the muscles on the thigh (hamstrings) might have intense action to cause this backward leg swing. The current results extended the previous research (Thelen et al., 2005; Thelen et al., 2006; Yu et al., 2008) that it is likely that the peak muscle stretching length, the intense concentric action thereafter, the transition from eccentric to concentric and the segment-interaction may induce strain injury in the hamstring muscle.

During the initial contact phase, the GRF passed anterior to the knee and hip joint, therefore, the GRF produced an extension torque at knee and flexion torque at hip joint, at this time, the MUS functioned mainly to counteract the GRT created by the GRF on the knee and hip joint, while other kinds of torques were less important and had no considerable contribution to the joint motion. The MUS and GRT have a peak value on the knee joint (203.40 ± 93.60 Nm, 96.82 ± 76.07 Nm) during initial stance phase as well on the hip joint (455.24 ± 198.72 Nm, 218.58 ± 130.99 Nm). The MUS flex the knee and extend the hip joint at the same time and to counteract the GRT of GRF. Therefore, the knee flexor (hamstring muscle is involved) was required to create a flexion torque in order to counteract the GRT, meanwhile, the GRF produced a large flexion torque at hip joint and it was

necessary for the hip extensor (hamstring muscle is also involved) to create an extension torque in order to counteract its effect. That means, the bi-articular muscle hamstrings must create torques at both the knee and the hip joint to neutralize the effect of GRT induced by the GRF. This may lead to the occurrence of hamstring muscle injury. Since the impact of GRF at

this stage is large, the required counteraction and hence the stress loading on knee flexor and hip extensor ought to be very large as well. If the strength of the hamstring muscle is not sufficient, it is susceptible to strain injury.