Research 1: Intersegmental Dynamics and its Relevance to Motor Control and Muscle Injury during Sprint Running

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±76.07Nm) during initial stance phase as well on the hip joint (455.24±198.72Nm, 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.
Research 2: The Neuromuscular Adaptation after 8 Weeks Weighted Counter-movement Jump

It has been revealed that Weight Training (WT) can promote maximal muscular strength most effectively, but it is not enough to change dynamic performance, while Plyometric Training (PT) can obtain effective promotion in movement speed, but it is limited in the development of maximal strength. To integrate the advantages of WT and PT, Plyometric Weight Training (PWT) was developed. The purpose of present study was to investigate the characteristics of kinematics, kinetics and neuromuscular adaptation after eight weeks PWT (Weighted Counter-movement Jump, WCMJ) with 30% MVC load in a total of 24 training sessions. Methods: 16 subjects who can squat 2.5 times of their body weight were selected from university male basketball team and were divided into the weight training group (load was 70% MVC) and the PWT group (load was 30% MVC). The Kistler force plate was used to record the ground reaction force. Maximum isometric strength was measured with plyometric weight training system upon Kistler's force plate by static squat lift which was considered as 100%MVC, and then the relevant parameters of strength diagnosis were recorded. The amplitude and latency time of the H-reflex, which is for the relevant neuromechanical parameter, was record by a biosignal analysis system. The pre- and after test were performed before and after the 8 weeks training. Two-way ANOVA was used for analyzing the differences of the parameters. Results: the increasing of isometric force (222.93 ± 65.30 to 320.21 ± 56.90 kg) of the weight training group was higher than the PWT group (225.06 ± 46.15 to 310.23 ± 54.42 kg). The changes of RFD for the PWT group (2445.48±1840.24 to 4047.57±2040.74 N/ms) was higher than the for weight training group (2544.58±1784.02 to 2645.37±1805.31 N/ms). In the PWT group, the muscle power after training (45.95±16.34 W/kg ) was higher than the power of before training (42.67±12.90 W/kg). After 8 weeks PWT, the ratio of Hmax/Mmax was significantly decreased (95.10±85.67 to 82.07±30.96 ) indicating that the exitation of a-motorneuropool was declined due to PWT. The reason for the decline of Hmax/Mmax is related to the pre-synaptic exhibition. The amplitude of T-reflex was significantly increased after 8 weeks PWT revealing that the sensitivity of Golgi tendon organ was decreased. Conclusion: The findings suggested that the muscle strength and power can be significantly improved and the neuromuscular adaptation was induced by PWT.