CHANGES IN RUNNING VELOCITY AND KINETICS OF THE LOWER LIMB JOINTS IN 100 m SPRINT RUNNING

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The purpose of this study was to investigate the changes in kinetics of the lower limb joints in 100 m sprint running. Nine male sprinters running 100 m with the maximum effort were videotaped at every 10 m from the start to 90 m mark with five high-speed cameras and five normal VTR cameras. Analyses of the relationship between changes in running velocity and the kinetics, joint torque, joint torque power, of the leg indicated that the critical joint kinetics factors in 100 m were: In the acceleration phase, the joint torque power exerted by the hip flexors in the early recovery phase and by the hip extensors in the late recovery phase; In the maintaining phase, the joint torque power exerted by the hip flexors in the early recovery phase and by the knee flexors in the late recovery phase.

KEY WORDS: 100 m sprint, running velocity, joint kinetics, power.

INTRODUCTION: Running is one of the basic human movements, and running fast is one of the most important athletic abilities in various sports. 100 m sprint of track and field is an event to compete human ability of maximum running velocity. Although changes in the velocity, stride length and stride frequency during 100 ms print race have been investigated, there is little information of the change in running motion, joint torque and joint torque power of the lower limb joints with the increase in the distance. The purpose of this study was to investigate the change in kinetics of the lower limb joints in 100 m sprint running.

METHODS: Nine male sprinters participated in this study (height: 1.72±0.03 m, body mass: 64.9±3.8 kg, 100 m personal best record: 10.83±0.36 s). Subjects running 100 m with the maximum effort were videotaped at every 10 m from the start to the 90 m mark with five high-speed cameras (250 Hz) and five normal VTR cameras (60 Hz). Two dimensional coordinates of the body landmarks (23 marks) were obtained by digitizing VTR images over at least one cycle. Digitized x and y coordinates of the body marks were smoothed by a Butterworth filter cutting off at 3.75~6.25 Hz. Since no force platform was used in the present study, ground reaction forces were estimated as the product of the body mass and the acceleration of the center of gravity. Stride length, stride frequency and joint angles were obtained by kinematics analysis. A linked-segment model was used to obtain joint torques about hip, knee and ankle joints. Joint torques were calculated with an inverse dynamics approach. Joint torque powers were calculated by multiplication of joint torque with joint angular velocity. These variables were compared between adjacent marks, every 10 m to identify the changes with the distance. To test the difference between the adjacent marks, Wilcoxon Signed-Rank Test was used, setting significant level at 5%.

RESULTS: Figure 1 shows the averaged pattern of the running velocity, stride length and stride frequency in 100 m sprint. The running velocity significantly increased from the 10 m to 40 m marks and significantly decreased between the 70 m to 90 m marks. The stride length increased from the 10 m to 30 m marks. The stride frequency significantly increased from the start to the 10 m mark, and decreased at the 70 m mark. Based on the changes in these performance descriptors, 100 m was divided into four stages: first acceleration, second acceleration, max velocity and deceleration, as shown in Figure 1. Figure 2 shows the peak torque power at the hip and knee joints in the recovery phase. The peak hip joint torque power in the early recovery phase (HP-ER) significantly increased at the 50 m mark and decreased at the 70 m mark. The peak knee joint torque power in the early recovery phase (KP-ER) significantly increased at the 20 and 50 m marks and decreased at the 70 m mark. The peak knee joint torque power in the late recovery phase (KP-LR) significantly increased at the 20, 40 and 50 m marks and decreased at the 70 m mark.

DISCUSSION: In the first acceleration stage, the peak values of HP-LR were already large at the 10 m mark. The peak values of KP-ER and KP-LR significantly increased at the 20 m mark. These results indicate that the increase in the knee joint torque power and the hip joint torque power in the recovery phase would closely relate to the increase in the stride length, stride frequency, and the running velocity in this stage. In the second acceleration stage, the running velocity and stride length significantly increased from the first acceleration stage. The joint torque power of the hip in the support phase increased from 10 to 30 m marks. These results indicate that the increase in the hip joint torque power in support phase would relate to the increase in the stride length and running velocity in this stage.

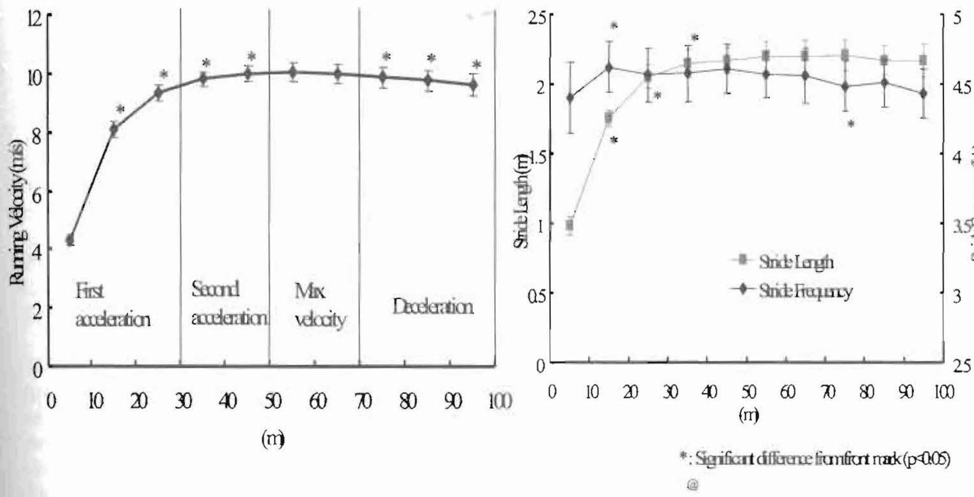

Figure1. Average patterns of the running velocity, stride length and stride frequency during 100 m at every 10 m.

In the max velocity stage, the peak joint torque power in recovery phase except HP-LR were the largest at the 50 m mark. The result indicates that the increase in the peak torque power, especially, the joint torque powers by the hip flexors in the early recovery phase and by the knee flexors in the late recovery phase would relate to attaining and maintaining the high running velocity in this stage. In the deceleration stage, the peak joint torque powers of the hip and knee in the recovery phase significantly decreased at the 70 m mark, and similar changes were found in the support phase. These results indicate that the joint torque powers by the hip flexors in the early recovery phase and by the knee flexors in the late recovery phase would be decreased by fatigue and result in the decreases in the stride frequency and running velocity in this stage.

CONCLUSIONS: The positive torque power of the hip joint in the recovery phase and the negative torque power of the knee joint in the late recovery phase played an important role in 100 m sprint running. It appears that the increase and decrease in the joint torques and joint torque powers do not always correspond with the change in running velocity, although they relate each other. Therefore, it was suggested that runners should strengthen the muscles around the hip joint and the eccentric exertion of the knee flexors.

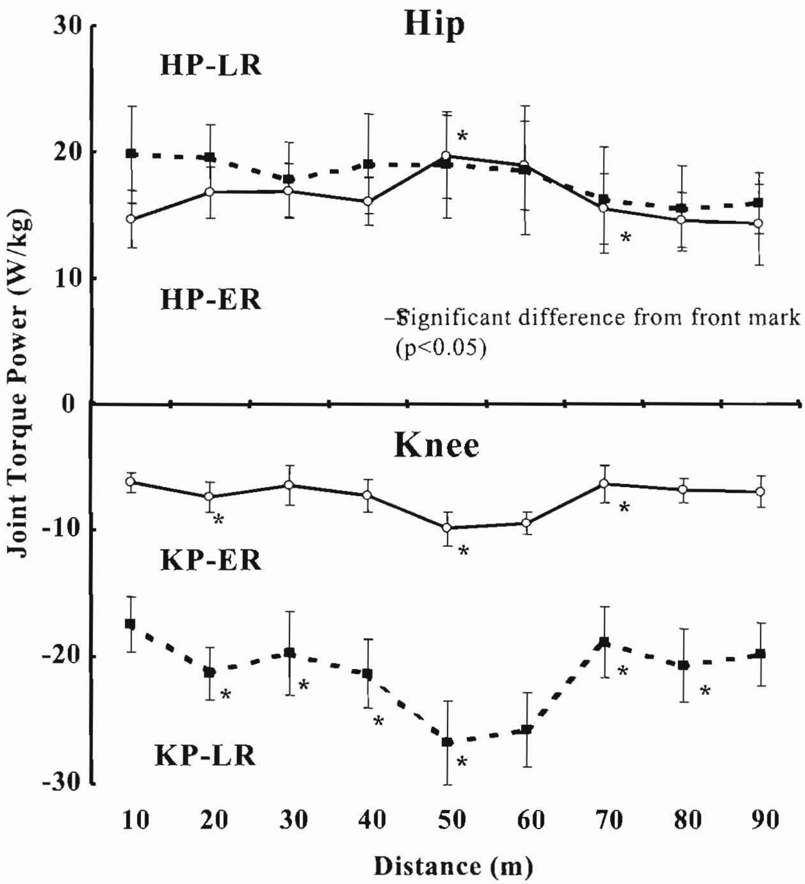

Figure 2. The peak torque powers at the hip and knee joints in the recovery phase.

REFERENCES:

Ae, M., Miyashita, K., Yokoi, T., Ooki, S. and Shibukawa, K. (1986) Mechanical powers and contributions of the lower limb muscles during running at different speeds. *Bull, Health & Sports Sciences, Univ. of Tsukuba* **9**, 229-239.

Baba, T., Wada, Y. and Ito, A. (2000) Muscular activity pattern during sprint running. Japan *Journal of Physical Education* **45**, 186-200.

Wells, R. P. and Winter, D. A. (1980) Assessment of signal and noise in the kinematics of normal, pathological and sporting gaits. *Human Locomotion*, **I**, 92-93.