EFFECTS OF PACING STRATEGIES ON THE RUNNING MOTION OF MALE 800 METER RUNNERS

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The purpose of this study was to investigate the effects of different pacing on running motion for male 800 m runners in official competitions. Ten male 800m runners were videotaped (60Hz) from the side positioned the marks of 150m (1st mark), 350m (2nd mark), 550m (3rd mark) and 750m (4th mark) of the 800m race. Kinematics and Kinetics variables were calculated. We divided ten subjects into two groups: Positive-type (POS) which consisted of five subjects with the fastest average running velocity of the 1st and 2nd marks running velocity (running velocity), Negative-type (NEG), which consisted of the five other subjects. In POS, the running velocity, the stride length per height and the shank angular velocity of the support leg were significantly decreased along the race, and the trunk inclined forward than NEG. However, the hip extensor torque, power and the knee flexor torque at the late recovery phase did not decrease. In NEG, the running velocity, the relative step frequency, the hip flexor torque at the early recovery phase, the hip extensor torque and the knee flexor torque at the late recovery phase were significantly increased at the late half of the race. The thigh and shank angular velocity of the support leg were maintained. It was concluded that the running motion of 800 m runners were affected by the pacing strategy.

KEY WORDS: middle-distance, running pace, biomechanics

INTRODUCTION: It is known that there are several pacing strategies, which affect the performance in middle-distance running. It is important for middle-distance runners and coaches to consider the pacing strategy according to their goals. In short sprinting or long-distance running, there are numerous biomechanical studies on the athletes' running motions. However few biomechanical studies on middle-distance running are seen. This may be partially explained by the varying nature of motion, which allows several pacing strategies to be used, and the difficulty in collecting data in official competitions. Therefore, the purpose of this study was to investigate the effects of different pacing strategies on the running motions of male 800 m runners in official competitions.

METHODS: One full running cycle of ten male 800 m runners (height 1.76±0.04 m, body mass 63.5±4.5 kg, and race record 1 min 49 sec 12±79) were videotaped (60Hz) with two cameras positioned at the marks of 150m (1st mark), 350m (2nd mark), 550 m (3rd mark) and 750m (4th mark) during official 800m races. Two calibration makers were fixed the curbstones of the track. Twenty-three body points and the two calibration makers were digitized and reconstructed in two-dimensions by a DLT method. The real coordinates were smoothed by a fourth-order Butterworth digital filter at cut off frequencies ranging from 2 – 8 Hz, which were decided by residual error method for each point. The kinematics of legs was calculated from the coordinates, and the joint torques and powers of recovery leg which were calculated by a two-dimensional inverse dynamics. The running velocity was calculated as an average horizontal velocity of the center of gravity during one running cycle. Differences among the four marks were obtained using a repeated measure ANOVA at significance level of 0.05.
800 m runners and coaches usually classify pacing strategies for 800 m races into positive in which the first half of the race is relatively-fast, or negative in which the first half of the race is relatively-slow. Because of that, we similarly divided the subjects into two groups: (1) Positive-type (POS), which consisted of the five subjects (height 1.75±0.02 m, body mass 62.0±5.6 kg, and race record 1 min 49 sec 15±1 sec 13) with the fastest average running

velocity of the 1st and 2nd mark running velocity, and Negative-type (NEG), which consisted of the five other subjects (height 1.78±0.04 m, body mass 64.9±2.9 kg, and race record 1 min 49 sec 08±34).

RESULTS AND DISCUSSIONS: Figure 1 show changes in the running velocity, stride length divided by the body height (SL/H) and relative stride frequency for each group.
In POS, the running velocity at the 1st and the 2nd marks were greater than in NEG. Particularly, at the 1st mark, the running velocity (1st>2nd,3rd,4th, $p<0.001$), SL/H (1st>3rd, $p<0.01$; 1st>4th, $p<0.001$) and relative stride frequency (1st>2nd, $p<0.05$) were considerably great. On the other hand, in the late half of the race, the relative stride frequency was maintained but the SL/H significantly decreased (2nd>4th, $p<0.01$) causing the running velocity (2nd,3rd>4th, $p<0.01$) and the non-support distance (2nd>4th, $p<0.01$) to decrease. In order to increase the non-support distance, it's important to exert great power during the support phase, so the support leg may play critical role in this phase. However, the present study will not make any reference to the kinetics of the support leg, since we did not measure ground reaction force.

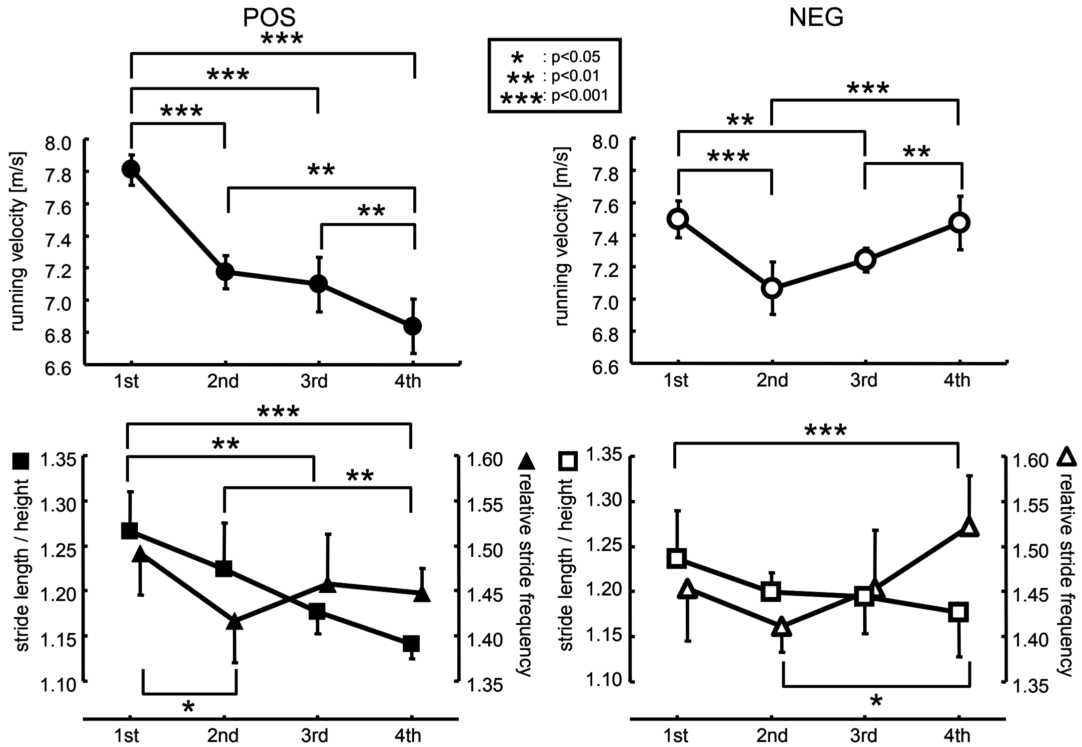

Figure 1 Changes in running velocity, SL/H and relative stride frequency for each group.

Figure 2 shows changes in the angular velocity of the thigh and shank of the support leg during the early and late support phases. In POS, the shank angular velocity during the early support phase significantly decreased from the 1st mark to the 3rd mark ($p<0.05$) and to the 4th marks ($p<0.001$). During the lately support phase, it significantly decreased at every mark relative to the velocity seen at the 1st mark (1st>2nd, $p<0.05$; 1st>3rd, $p<0.001$; 1st>4th, $p<0.01$). It was compares favorably to the changes due to fatigue found by Enomoto (2003) in the late half of 5000 m race.
Figure 3 shows hip and knee joint torque, angular velocity and power curves of the recovery leg during one cycle at each mark. In POS, the peak hip extensor torque of the late recovery phase (PTH2) and the peak knee flexor torque of the late recovery phase (PTK2) at the 1st and 4th marks (PTH2: 1st>2nd,3rd, 2nd<4th, $p<0.01$; 3rd<4th, $p<0.05$; PTK2: 1st<2nd, $p<0.01$; 1st<3rd, $p<0.05$) and the peak positive hip power of the late recovery phase (PPH2) at the 3rd and 4th marks (no significance) were considerably great. Haneda et al. (2003) reported

decreased PTH2, PPH2 and PTK2 in the deceleration phase of 100m race, and Enomoto (2003) found similar changes in the late half of 5000m race. But in this study, in POS, PTH2, PPH2 and PTK2 didn't decrease even when the running velocity was decreased. The trunk was more leaned forward in POS than in NEG, except at the 2nd mark. In such posture, the pelvis is inclined and the biceps femoris may be stretched. In drop jumping motion, it's effective to rotate the pelvis forward at the instant of foot contact with the ground to maximize hip extension power of the biceps femoris (Kigoshi et al. 2004). Therefore, it is possible that in POS subjects could generate higher PTH2, PPH2 and PTK2 not only at the 1st mark but also in the late half of the race by more easily extending the hip with the trunk more inclined forward.

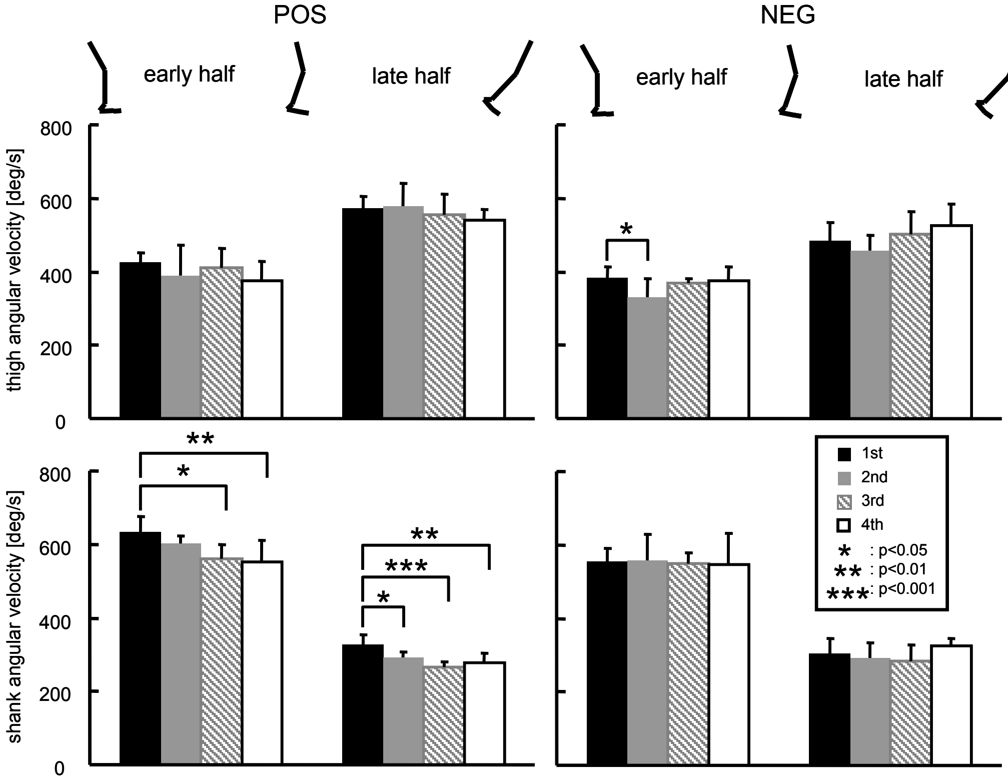

Figure 2 Changes in the average angular velocity of thigh and shank for support leg during early and late support phase.

In NEG, changes in the running velocity at the 1st and 2nd marks were similar than that in POS, but significantly increased from the 2nd to the 4th mark ($p<0.001$) as a consequence of a larger the relative stride frequency ($p<0.05$), which was increased by decreasing the late support time and non support time ($p<0.05$). Therefore, to increasing stride frequency it is important to move the leg faster. The peak hip flexor torque of the early recovery phase (PTH1) at the 4th mark and the peak positive hip power of the early recovery phase (PPH1) at

the 3rd and 4th marks were large (no significance), as were the PTH2 (3rd<4th, $p<0.05$), PPH2 (no significance), PTK2 (1st>4th, $p<0.05$; 2nd,3rd > 4th, $p<0.01$) and the peak knee flexor torque of the late recovery phase (PPK2) (2nd,3rd > 4th, $p<0.05$) at the 4th mark. The PTH1 at the 4th mark (10% normalized time) occurred earlier than at all other marks, which suggests that to increase stride frequency at the late half of 800m race, it is important to exert great hip flexion torque immediately after the toe off and great hip extension and knee flexion torque in the late recovery phase of the running cycle. Ae et al. (1986) stated that the hip flexors played an important role in pulling forward the recovery leg in the early recovery phase, while the knee flexors decelerated the forward rotation of the shank precipitating its contact with the ground. In this study, it was concluded that the stride frequency was increased by exerting negative power at knee and positive power at the hip, which ultimately increased the running velocity. In the late support phase, subjects in NEG increased the thigh angular velocity of the support leg and maintained the shank angular velocity from the 2nd to the 4th mark. This rapid motion of the leg shortens the late support time. However, the early support time and distance increased, which on the contrary, may decrease stride frequency and running velocity. According to a previous study by Enomoto and Ae (2004), it is advised to learn the shank of the support leg forward immediately after the foot contact with the ground, because the shank can minimize the loss of running velocity after foot contact (Ae et al. 1983). Therefore, to maintain or increase running velocity at the late half of the race it is important to lean the shank of the support leg forward immediately after the foot contact with the ground.

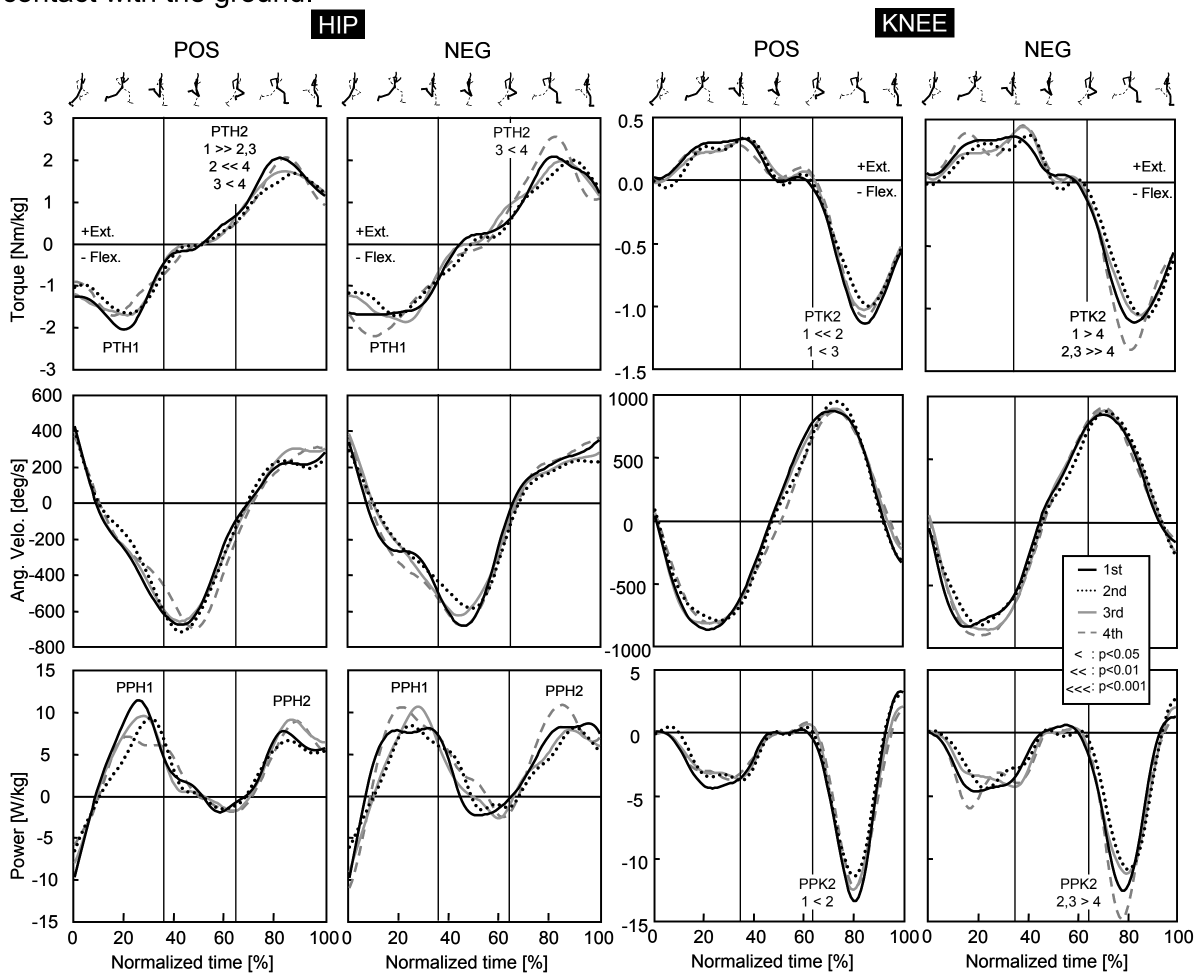

Figure 3 The average patterns of hip and knee joint torque, joint angular velocity and power at hip joint for each stage.

In conclusion, the results of this investigation revealed that the pacing strategy affects the running motion of 800m runners.

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