



The effect of locally braking crank rotation during pedaling on the pedaling force and activation of lower limb muscles

Soya Iwata¹✉, Takaki Yamagishi^{2,3}, Tomotaka Horiuchi³, Yoichi Tokuyasu⁴, Shigeru Wesugi^{3,5}, Yasuo Kawakami^{2,3}

Abstract

Introduction: In competitive cycling, pedaling efficiency is one of the key factors and it can be improved by the smooth pushing, pulling back and pulling up movements. Considering the mechanisms of human adaptive movements, we devised an approach to improving pedaling efficiency (fig. 1). This study aimed to clarify the effect of locally braking crank rotation during the pull up phase on the pedaling force and activation of lower limb muscles.

Methods: Ten male experienced cyclists (age: 21.3 ± 0.8 year, height: 171.5 ± 3.2 cm, mass: 66.7 ± 6.2 kg, VO_{2peak} : 66.7 ± 3.6 ml/min/kg) and ten untrained males (age: 21.4 ± 0.5 year, height: 172.2 ± 2.6 cm, mass: 62.0 ± 3.8 kg) participated in this study. Upper vertical position of the crank was defined as 0° , and one rotation was divided into four pedaling sections [push phase (300° to 30°), push-down phase (30° to 120°), pull-back phase (120° to 210°), pull-up phase (210° to 300°)]. Subjects cycled for 5 min with the locally braking (by adding resistance) from 210° to 240° of the right leg (the left leg) (from 30° to 60° for the left (the right)) as an intervention. Before and after the intervention, the subject performed 2-minute normal (without locally braking) pedaling while tangential pedaling force and surface electromyography (sEMG) of lower limb muscles (right: tibialis anterior (TA), medial gastrocnemius (MG), biceps femoris (BF), left: semitendinosus (ST) left: vastus medialis (VM), vastus lateralis (VL), rectus femoris (RF)) were measured. Pedaling efficiency was calculated as follows.

$$\text{Pedaling efficiency} = 100 \times \frac{\text{Tangential pedaling force}}{\text{Total pedaling force}}$$

Results: After the intervention, tangential force of experienced cyclists increased significantly from 150° to 270° (i.e. pull-back phase) and decreased significantly from 30° to 90° , (i.e. push phase) (Fig. 2). The tangential force of untrained men increased significantly from 180° to 240° (i.e., pull-back to up phases) (Fig. 3). The pedaling efficiency of experienced cyclists increased significantly from 60° to 240° (Fig. 4) while in untrained men the pedaling efficiency increased significantly from 90° to 120° and 180° to 210° (Fig. 5). In experienced cyclists, muscle activity of ST increased significantly in the 120° to 240° , while it was decreased from 300° to 330° , VM activity increased significantly from 30° to 60° and 300° to 330° , and MG increased

significantly from 240° to 270° (Fig. 6). In untrained men, activity of lower limb muscles did not change significantly.

Discussion: Results suggest that experienced cyclists increased the tangential force and muscle activity of ST as preparatory actions before the locally braking and it lasted after the intervention. Pedaling efficiency also increased in the pull-down and pull-back phases. Increased muscle activity of ST in the pull-back phases is in line with a previous study showing that muscle volume of ST was significantly greater in experienced cyclists than in untrained men (Ema et al.,2015). Increased muscle activity of VM in experienced cyclists in the push phase indicates the effect of local braking intervention on the performance of this phase. No change in muscle activities or tangential forces in the locally braked section in untrained men may reflect the fact that untrained men did not improved preparatory actions for this phase after the intervention. Collectively, it was suggested that the present local braking is more effective for experienced cyclists than untrained men. It is noteworthy that the local braking intervention is effective even in experienced cyclists.

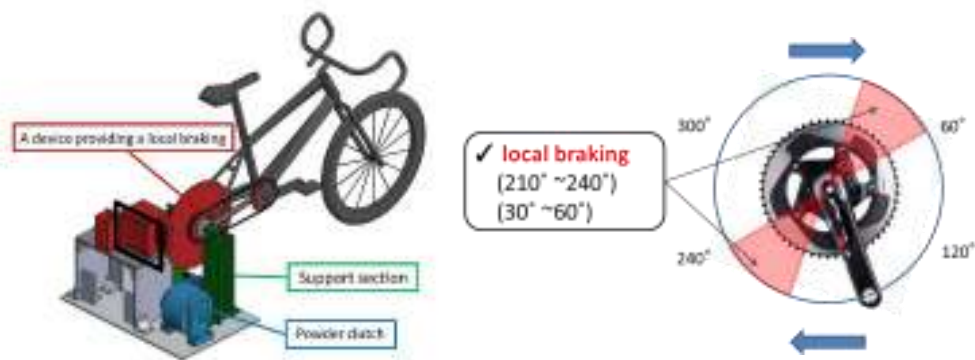


Figure 1. Training equipment with locally braking crank rotation.

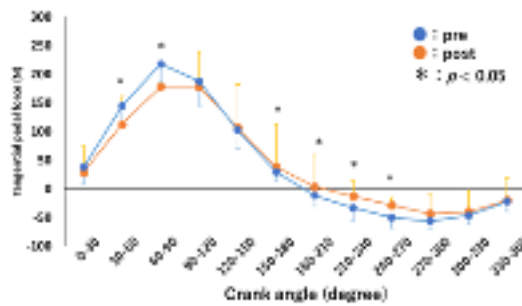


Figure 2. Tangential pedal force of experienced cyclists

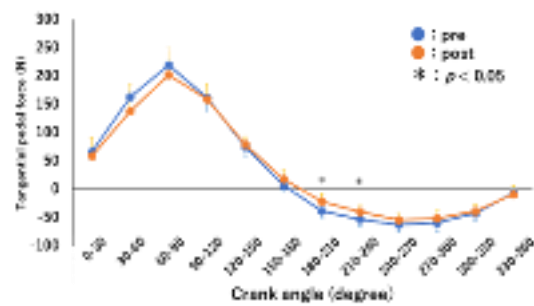


Figure 3. Tangential pedal force of untrained men

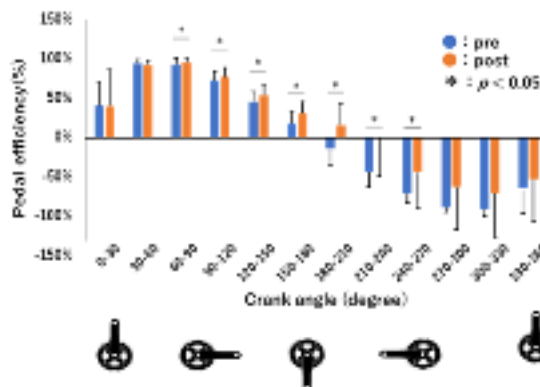


Figure 4. Pedaling efficiency of experienced cyclists

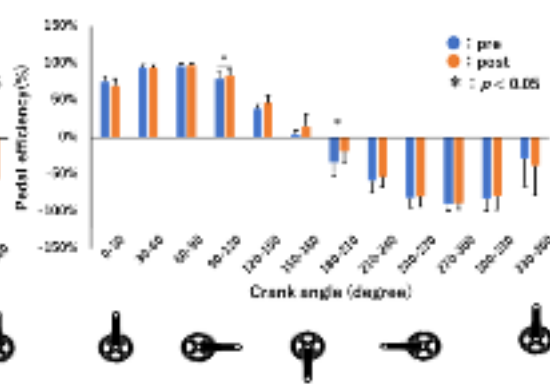


Figure 5. Pedaling efficiency of untrained men

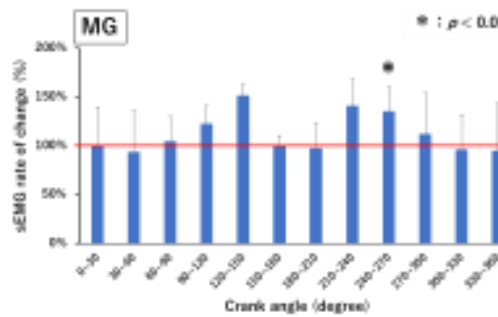
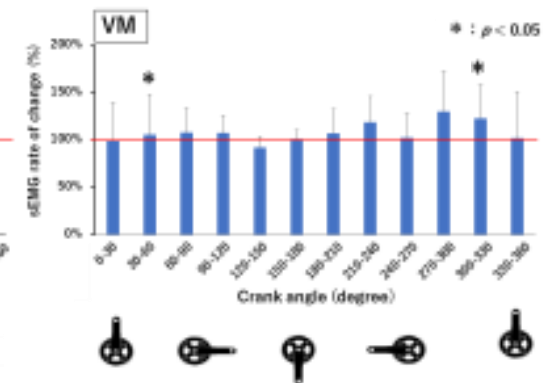
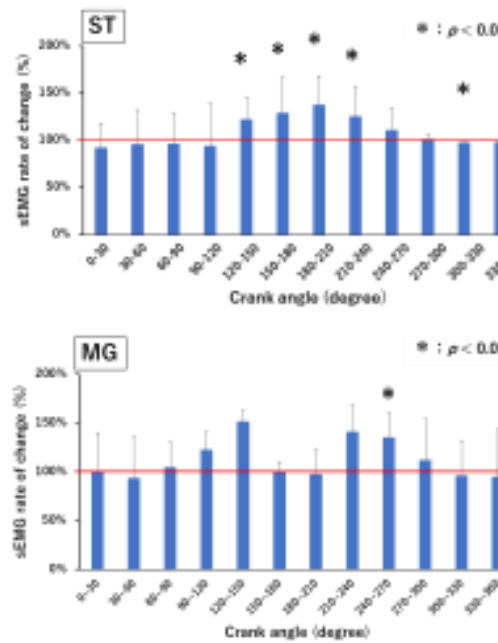


Figure 6. Relative changes in muscle activities in experienced cyclists.

✉ Contact E-mail: soyabmx@asagi.waseda.jp (S,Iwata)

¹School of Sport Sciences, Waseda University. ²Faculty of Sport Sciences, Waseda University. ³Human Performance Laboratory, Waseda University. ⁴Graduate School of Creative Science and Engineering, Waseda University. ⁵Faculty of Science and Engineering, Waseda University.