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

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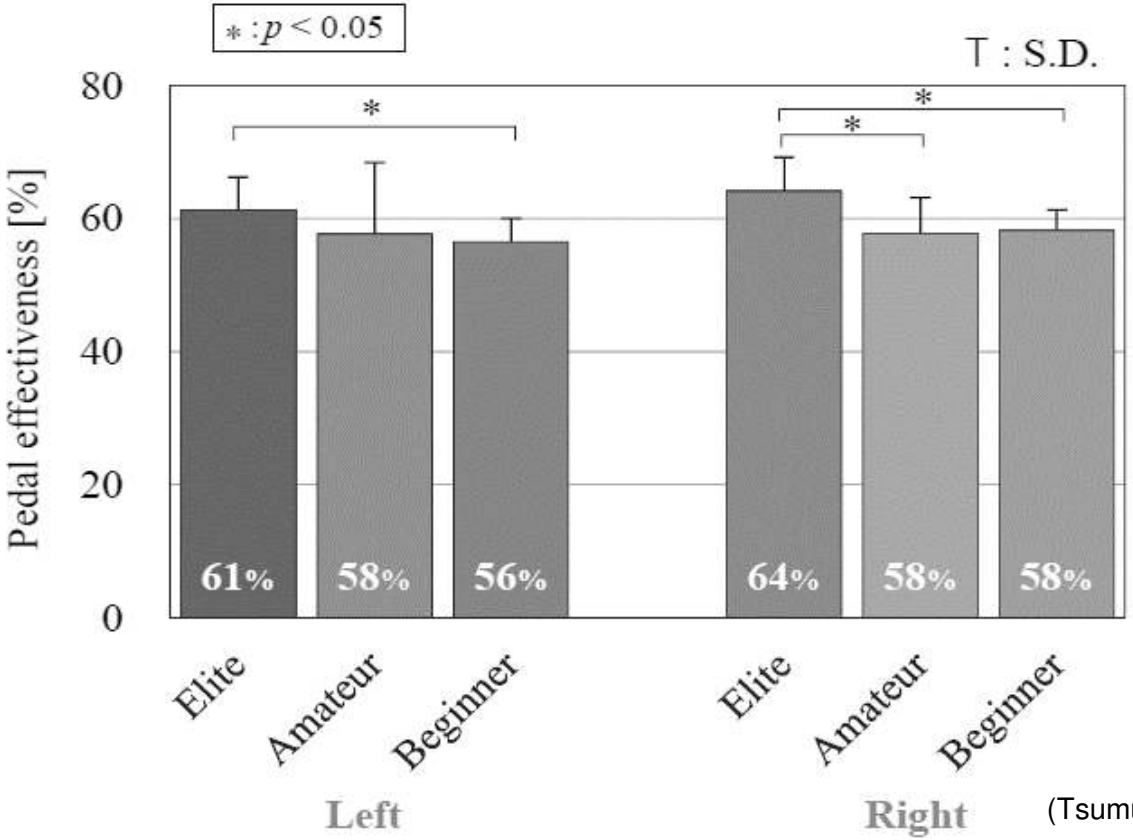
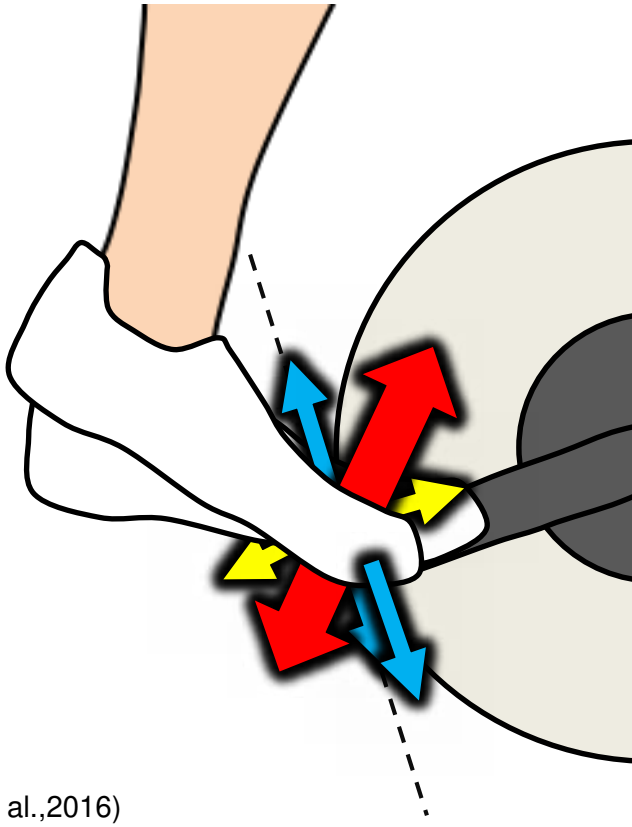
Introduction

Pedaling efficiency

✓Ratio of perpendicular force to the crank and total force applied to the pedal





(Tsumugiwa et al.,2016)

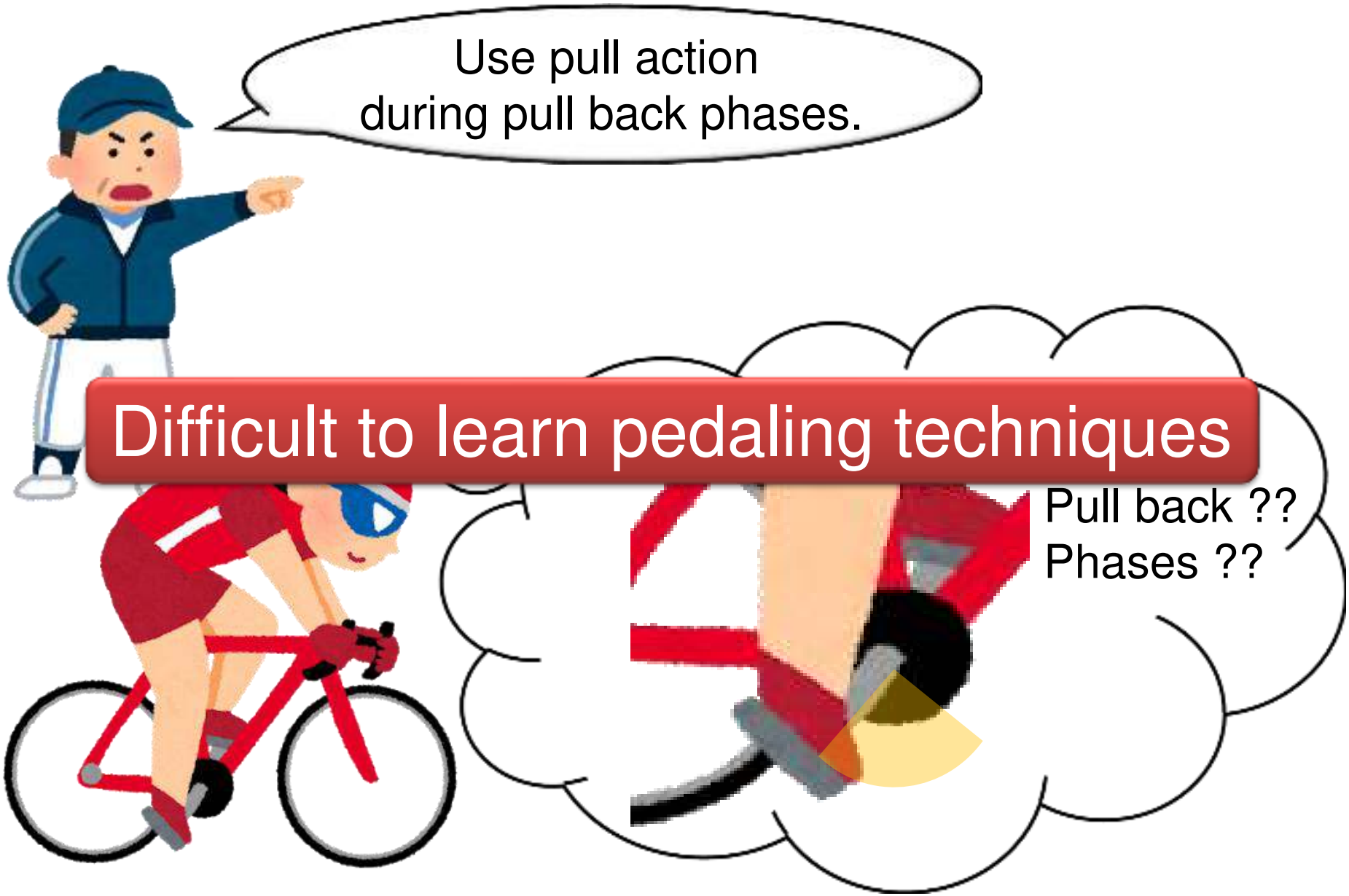
✓Elite cyclists perform pedaling at a higher efficiency than beginners.

(Takaishi et al., 1998; Tsumugiwa et al.,2016)

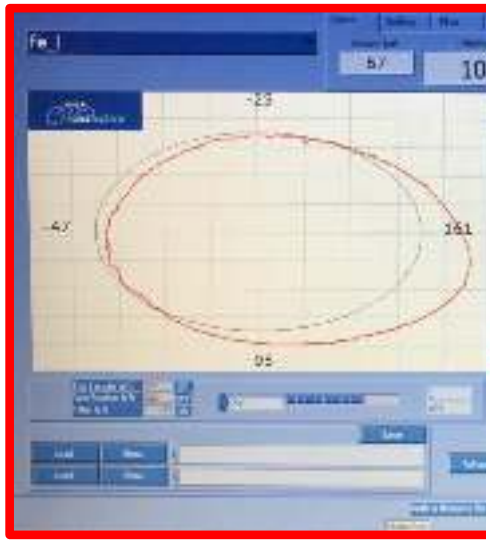
✓Pedaling efficiency can be improved by a better pull action.

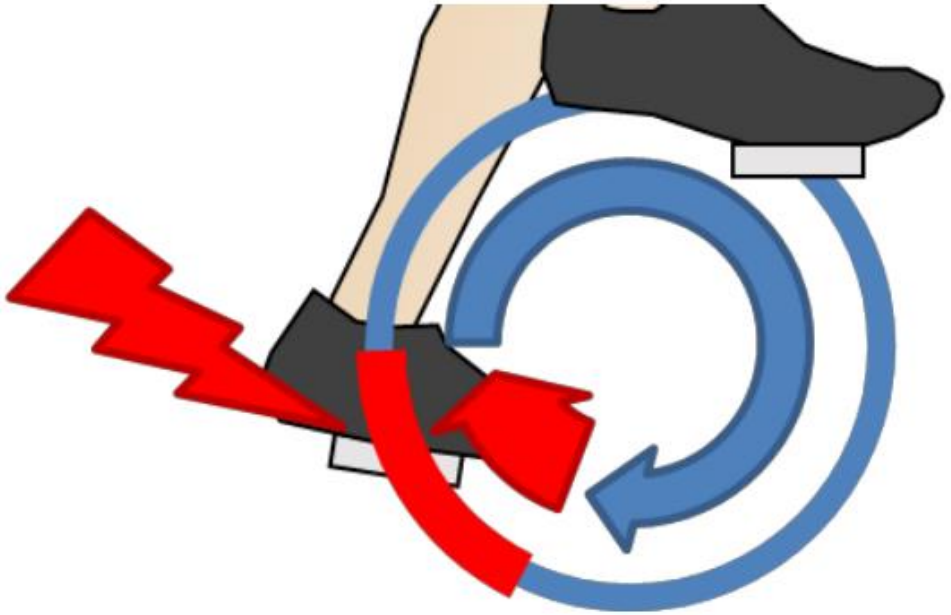
(Korff et al., 2007; Mornieux et al., 2008; Theurel et al., 2012)

Introduction



Introduction





Purpose

To clarify the effect of locally braking crank rotation during the pull-up phases on the pedaling force and activities of lower limb muscles.

Methods: Participants

✓10 male experienced cyclists

age：21.3±0.8 years
height：171.5±3.2 cm
mass: 66.7±6.2 kg

All cyclists had at least 3 years (5.4 ± 1.5 years) of racing experience
9 cyclists had won a prize or participated
in national college competition..

✓10 inexperienced men

age: 21.4±0.5 years
height: 172.2±2.6 cm
mass: 62.0±3.8kg

The inexperienced men had no experience in riding with clipless pedals.

Methods: Pedaling phases

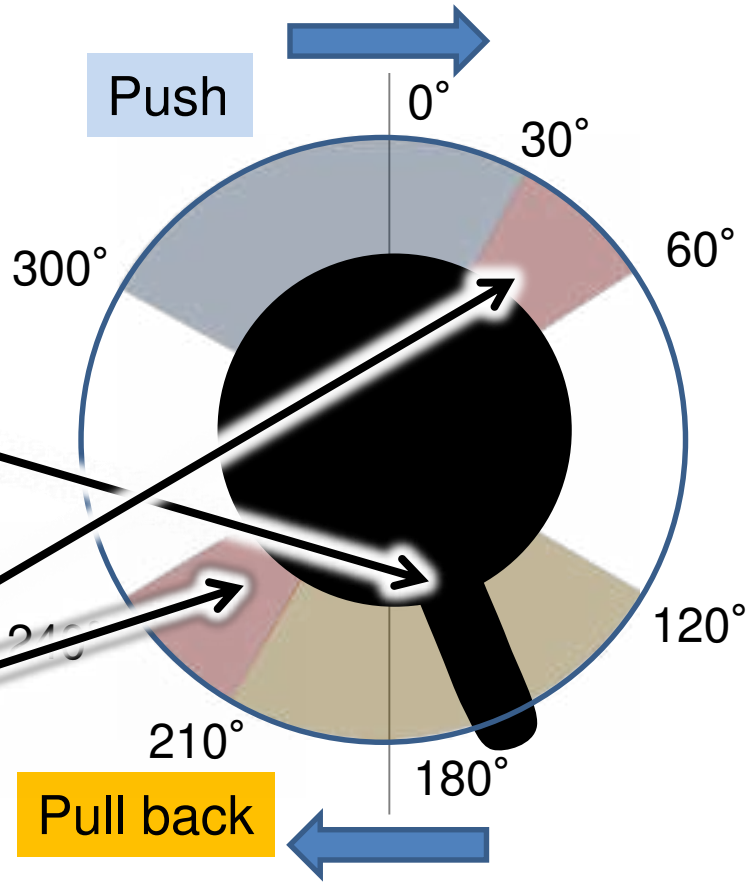
✓One rotation was divided into four pedaling phases.

- Push
(300° ～30°)
- Push down
(30° ～120°)

✓**Pull back**
(120° ～210°)

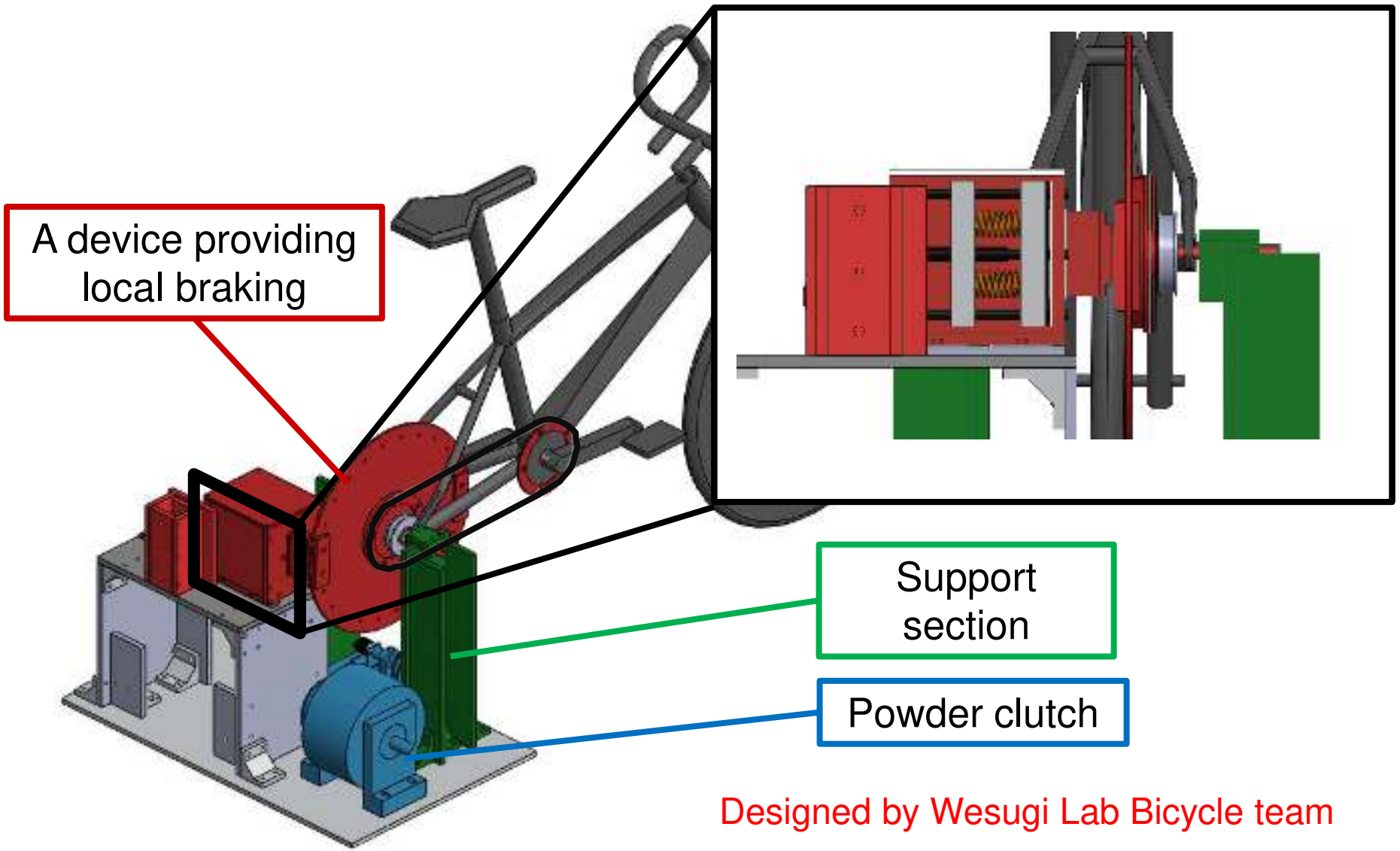
- Pull up
(210° ～300°)

✓ **Local braking**
(210° ～240°)
(30° ～60°)



✓Top dead center of right crank was defined as 0˚.

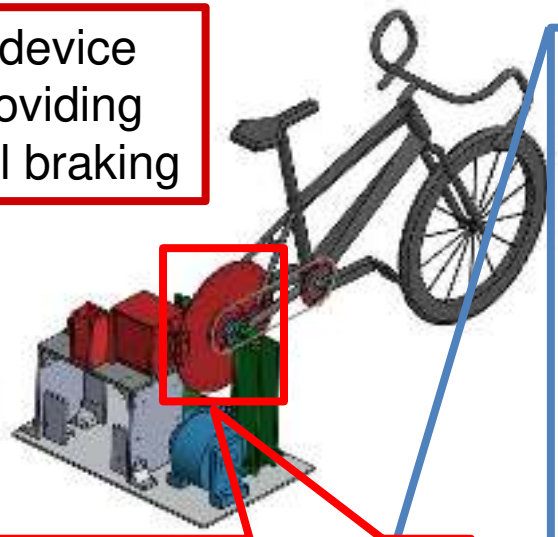
Training equipment with locally braking crank rotation.

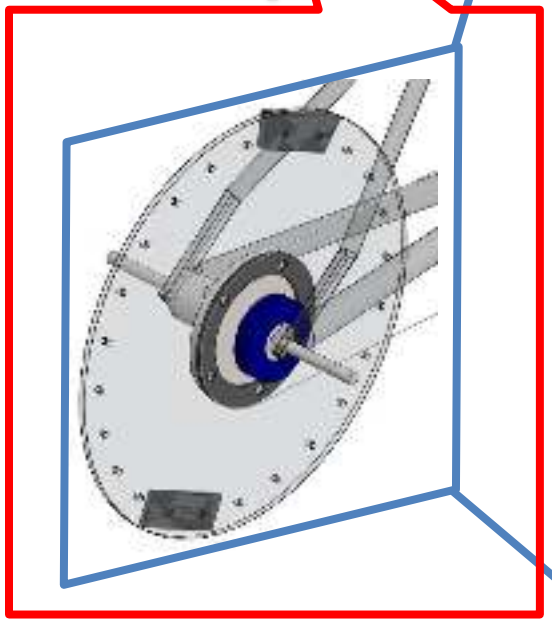


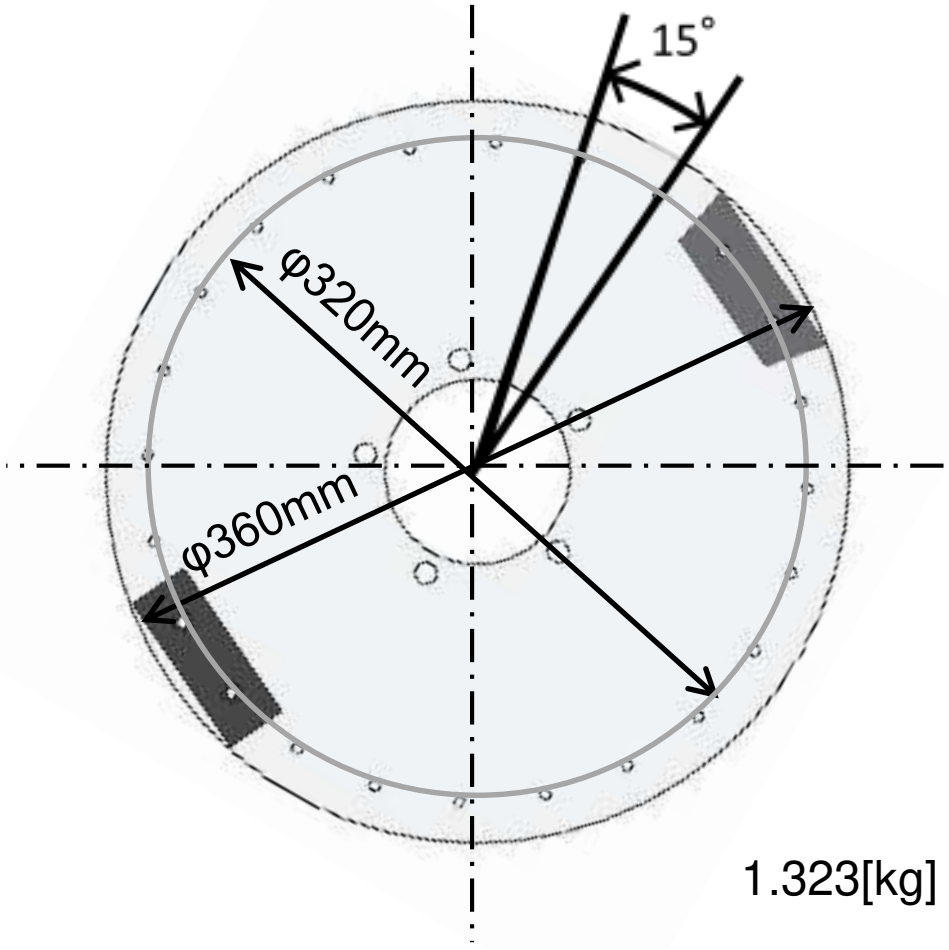
Designed by Wesugi Lab Bicycle team

Methods: Training equipment

A device providing local braking

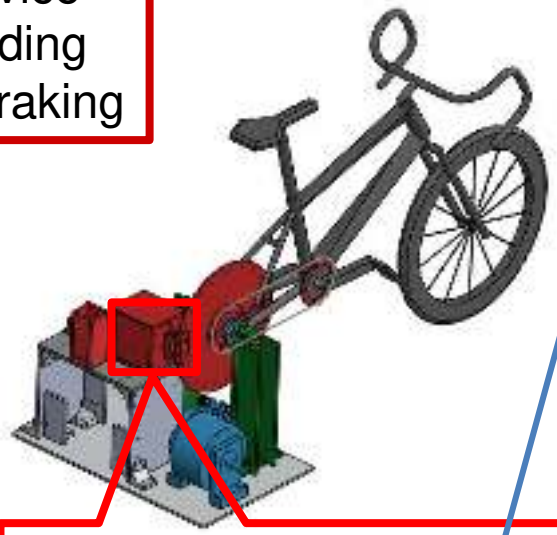


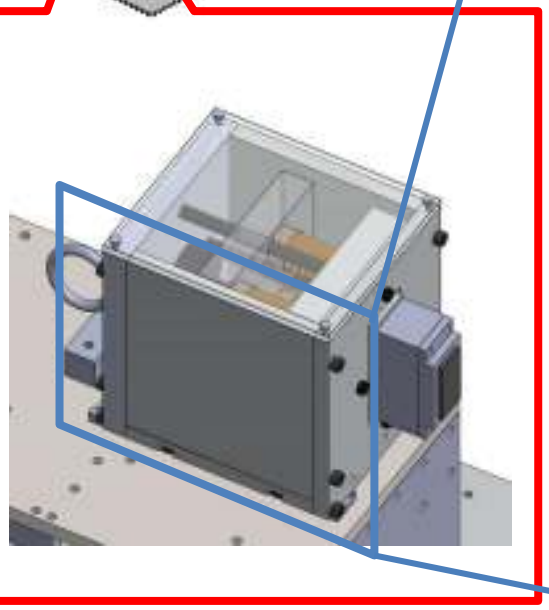




Designed by Wesugi Lab Bicycle team

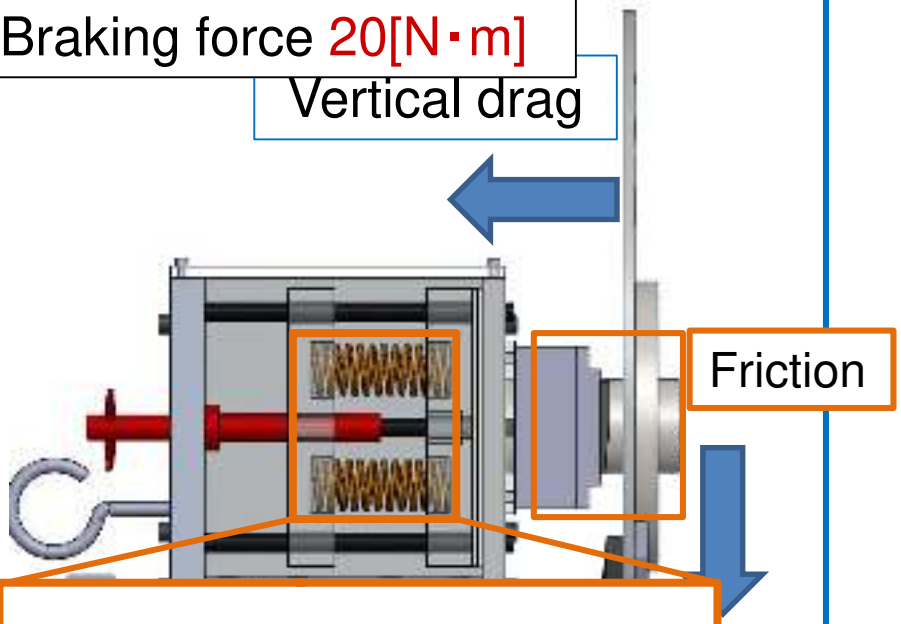
A device providing local braking

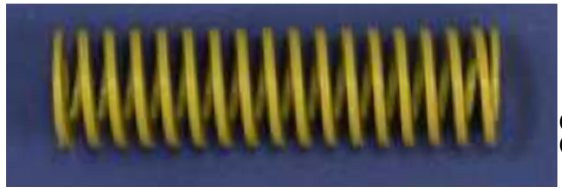




Braking force 20[N・m]

Vertical drag





Spring rate 9.81[N/mm]

Designed by Wesugi Lab Bicycle team

Methods: Training equipment

Methods: Design of experiment

2-min normal pedaling 80rpm 200w

5-min pedaling with the local braking 80rpm 100w

2-min normal pedaling 80rpm 200w

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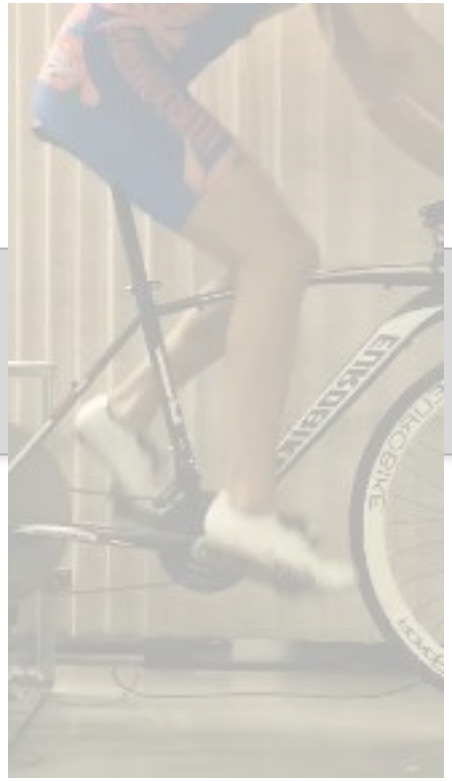

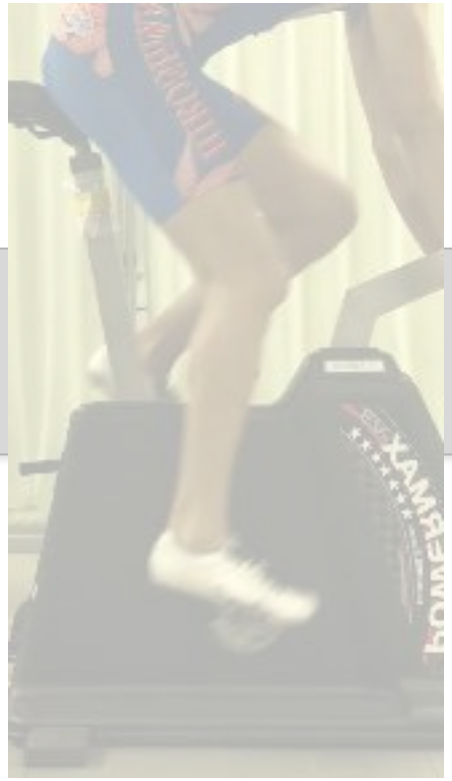

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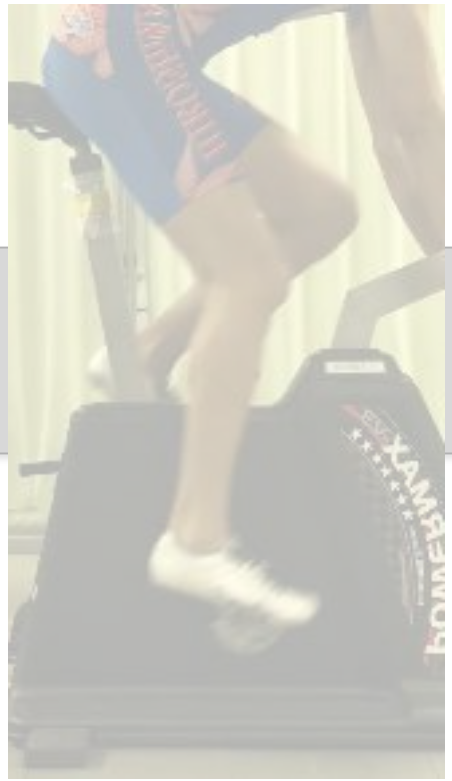

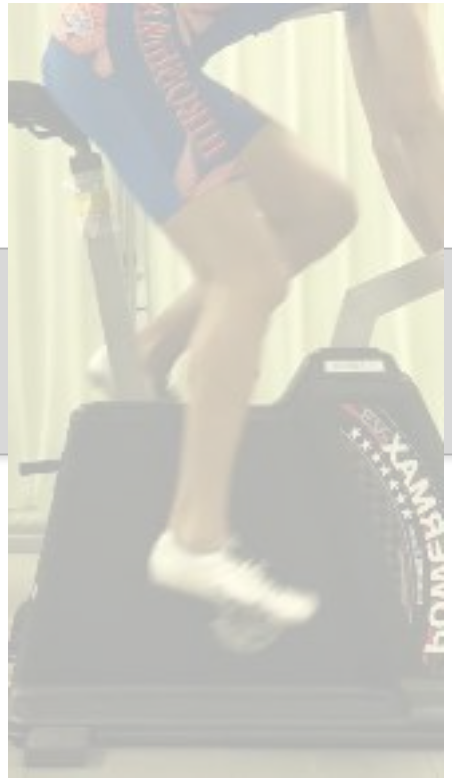

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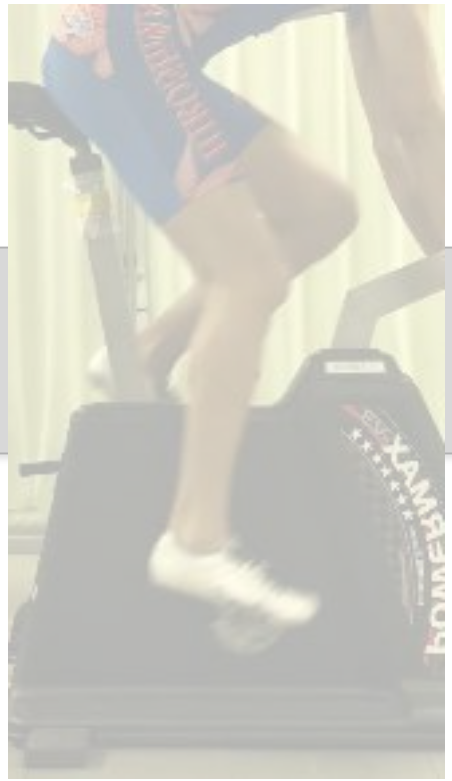
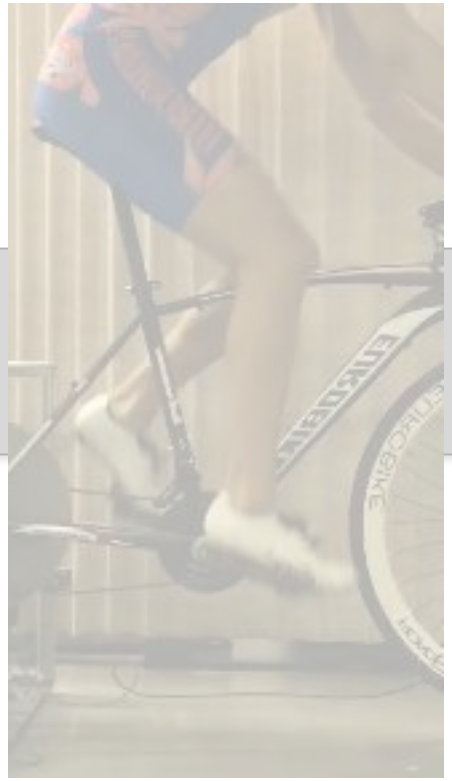




Methods: Design of experiment

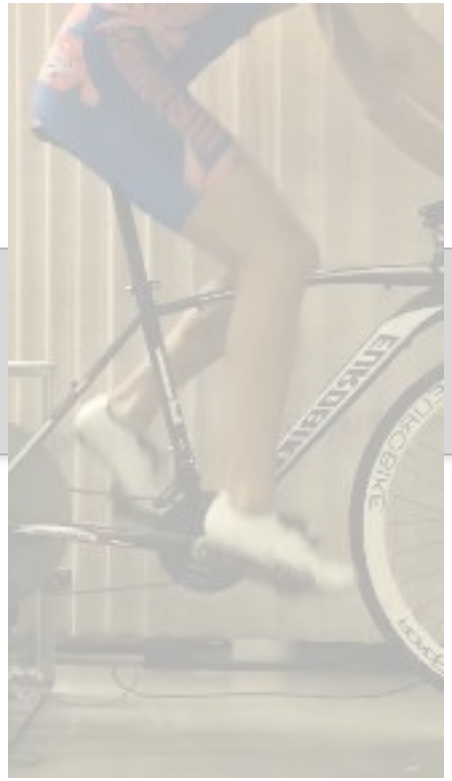
Pre

2-min normal pedaling 80rpm 200w

5-min pedaling with the local braking 80rpm 100w

Post

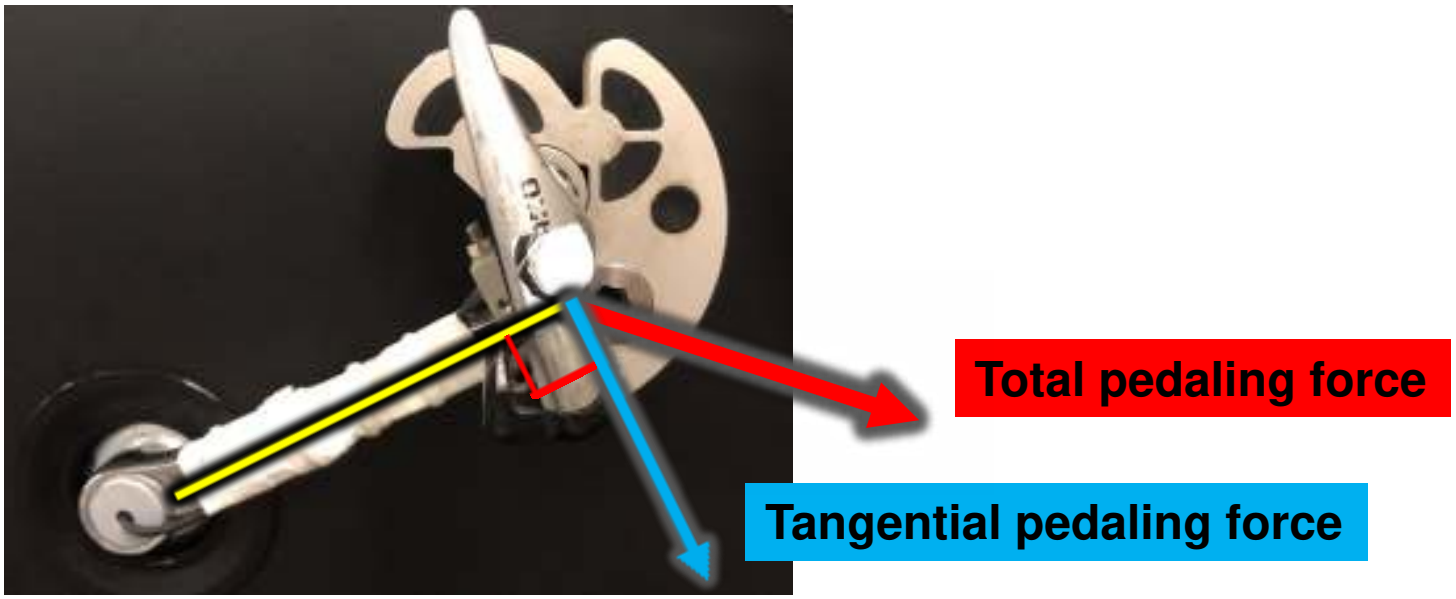
2-min normal pedaling 80rpm 200w



Methods: Tangential pedaling force

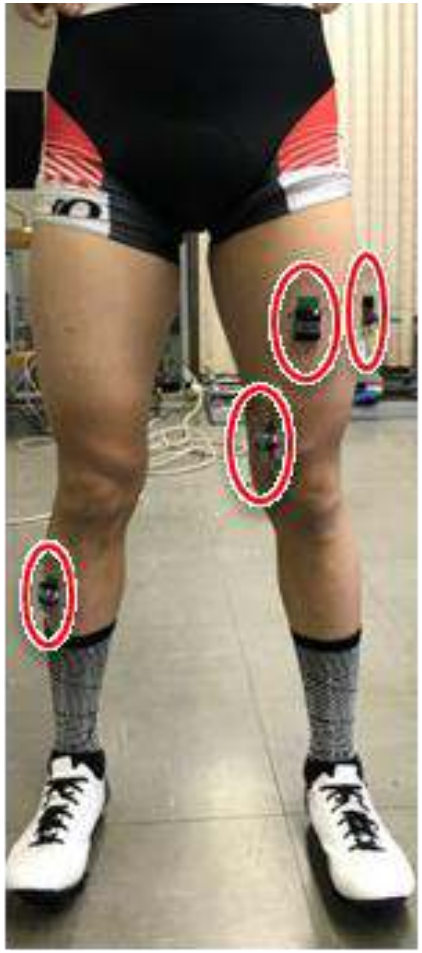
✓The vertical component to the crank was defined as **tangential pedaling force**.

✓Effectiveness of pedaling can be evaluated by the relative size of tangential pedaling force.



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

(Korff et al., 2007)

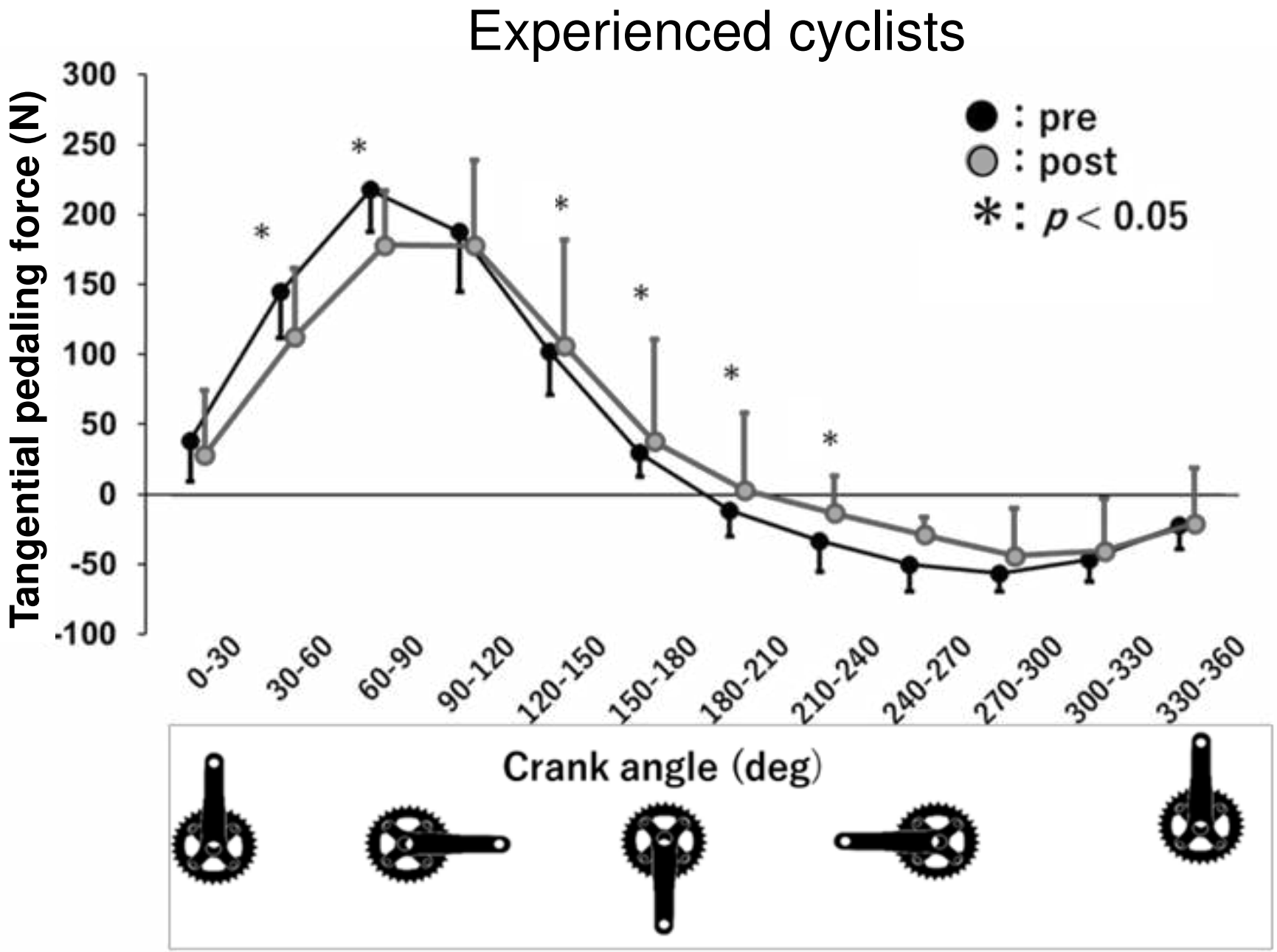


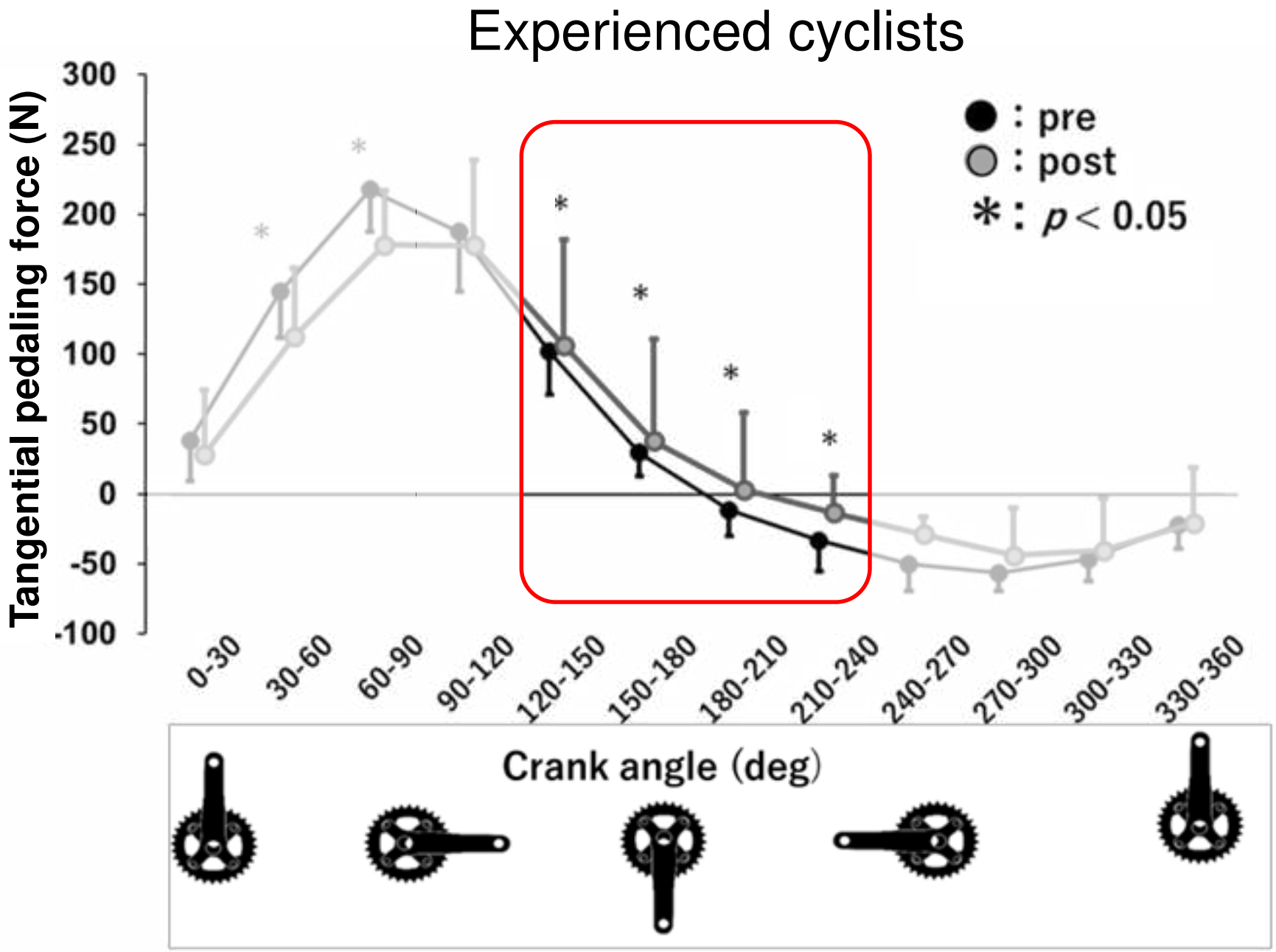
Right:
tibialis anterior (TA)
lateral gastrocnemius (LG)
biceps femoris (BF)
semitendinosus (ST)

Left:
vastus medialis (VM)
vastus laterelis (VL)
rectus femoris (RF)

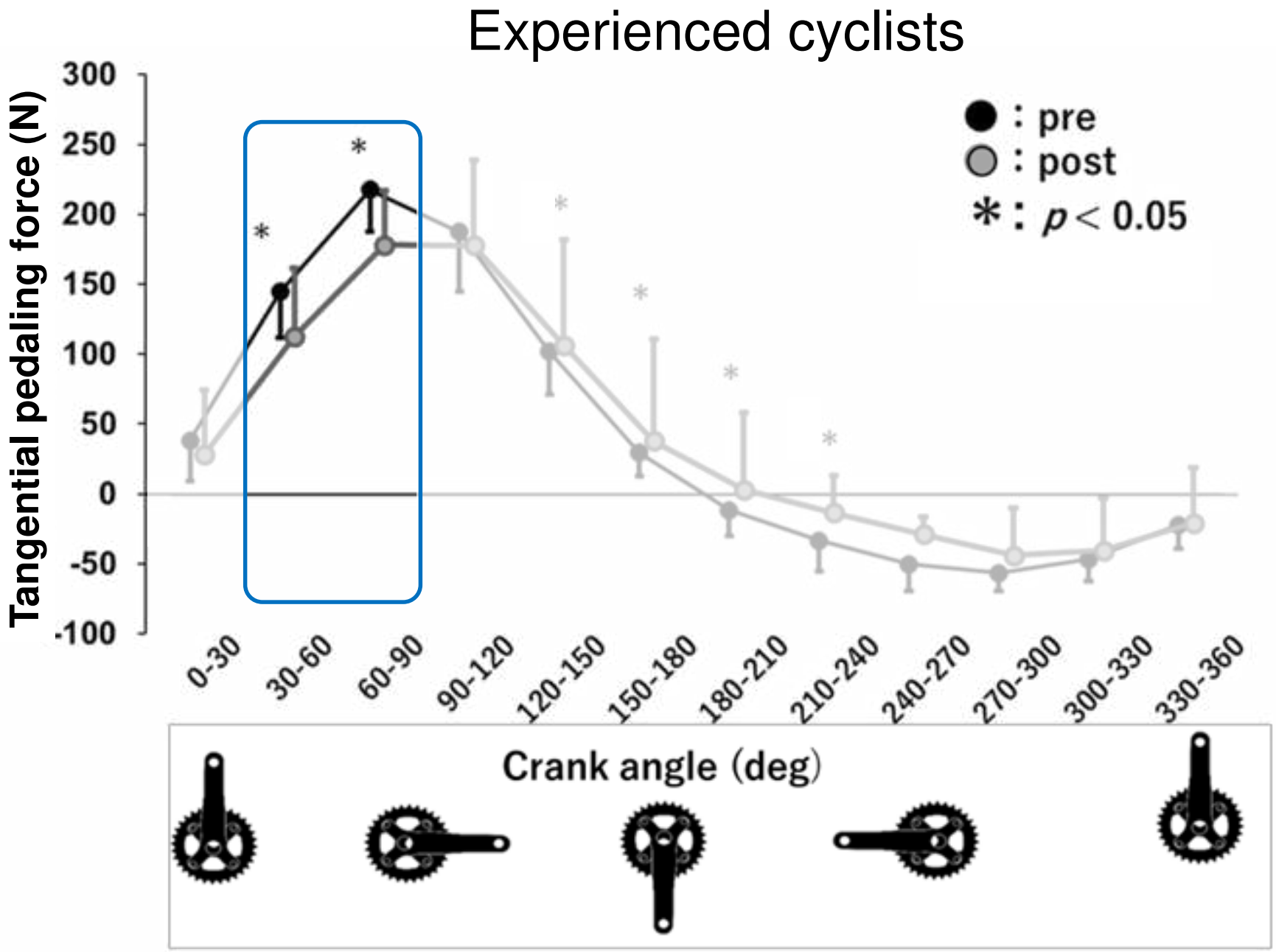
$$\text{Relative changes of muscle activity (\%)} = \frac{\text{Post root mean square of sEMG}}{\text{Pre root mean square of sEMG}} \times 100$$

Results: Tangential pedaling force

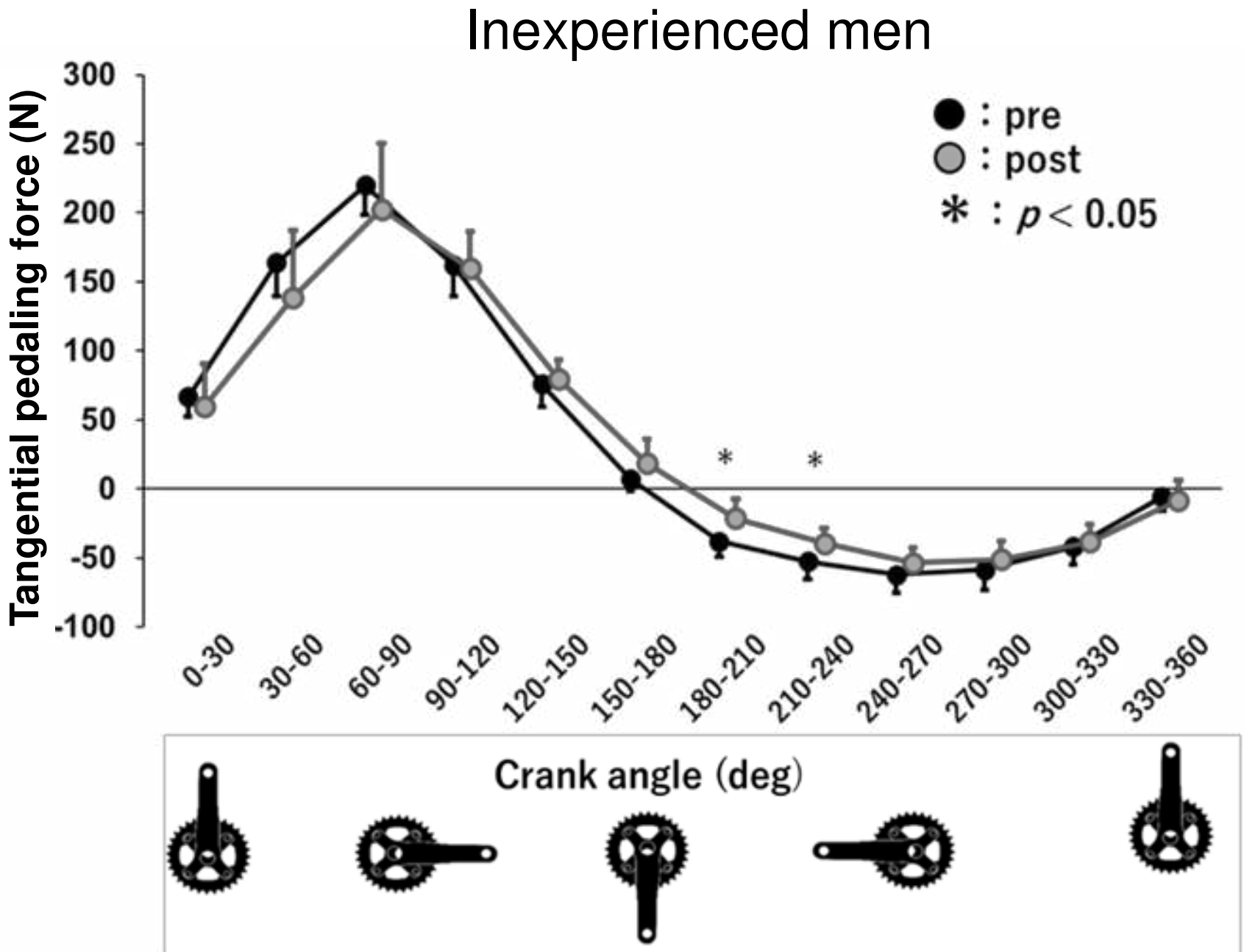



Experienced cyclists
Tangential pedaling force (N)
300
250
200
150
100
50
0
-50
-100
● : pre
○ : post
＊: $p < 0.05$
0-30
30-60
60-90
90-120
120-150
150-180
180-210
210-240
240-270
270-300
300-330
330-360
Crank angle (deg)

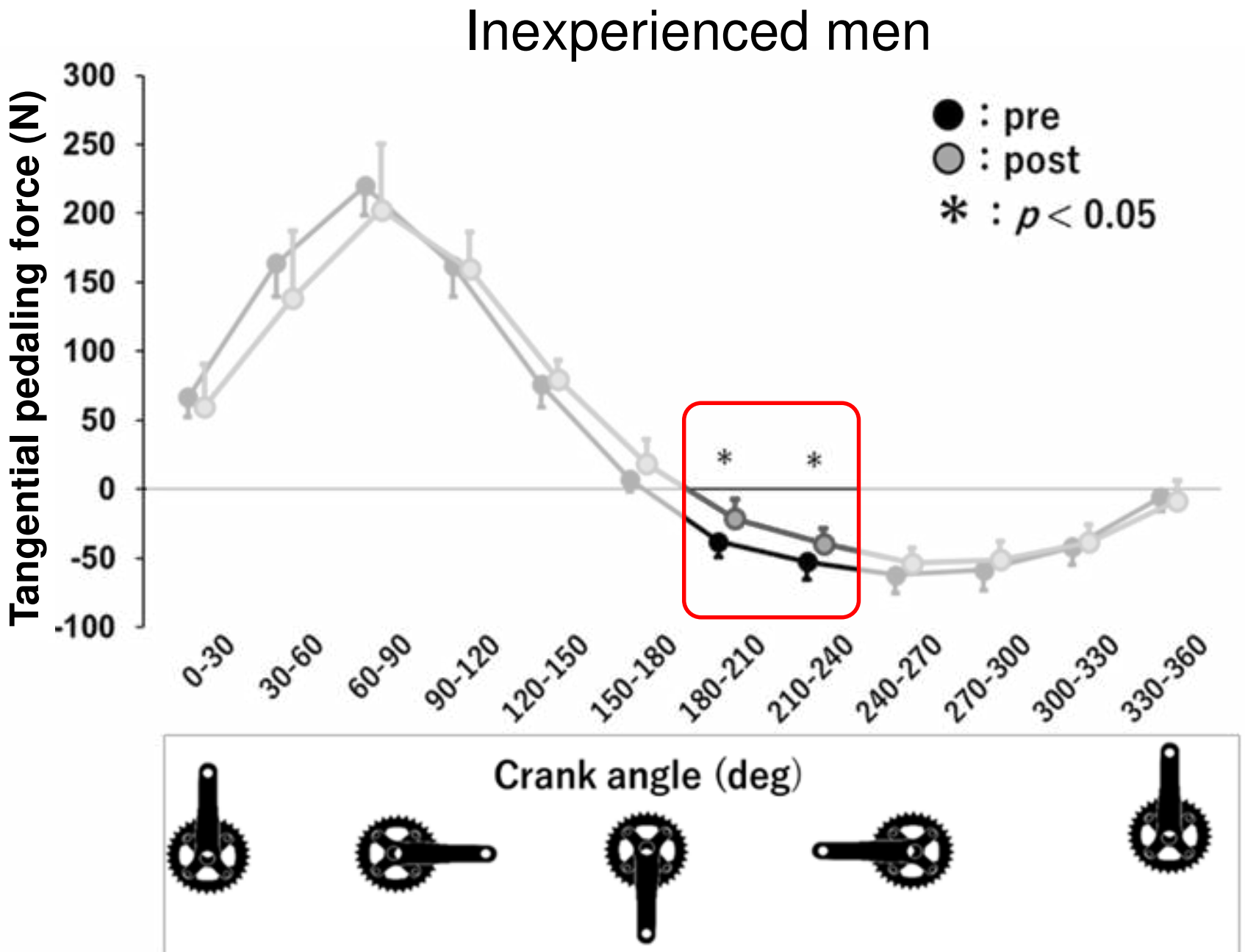
Results: Tangential pedaling force



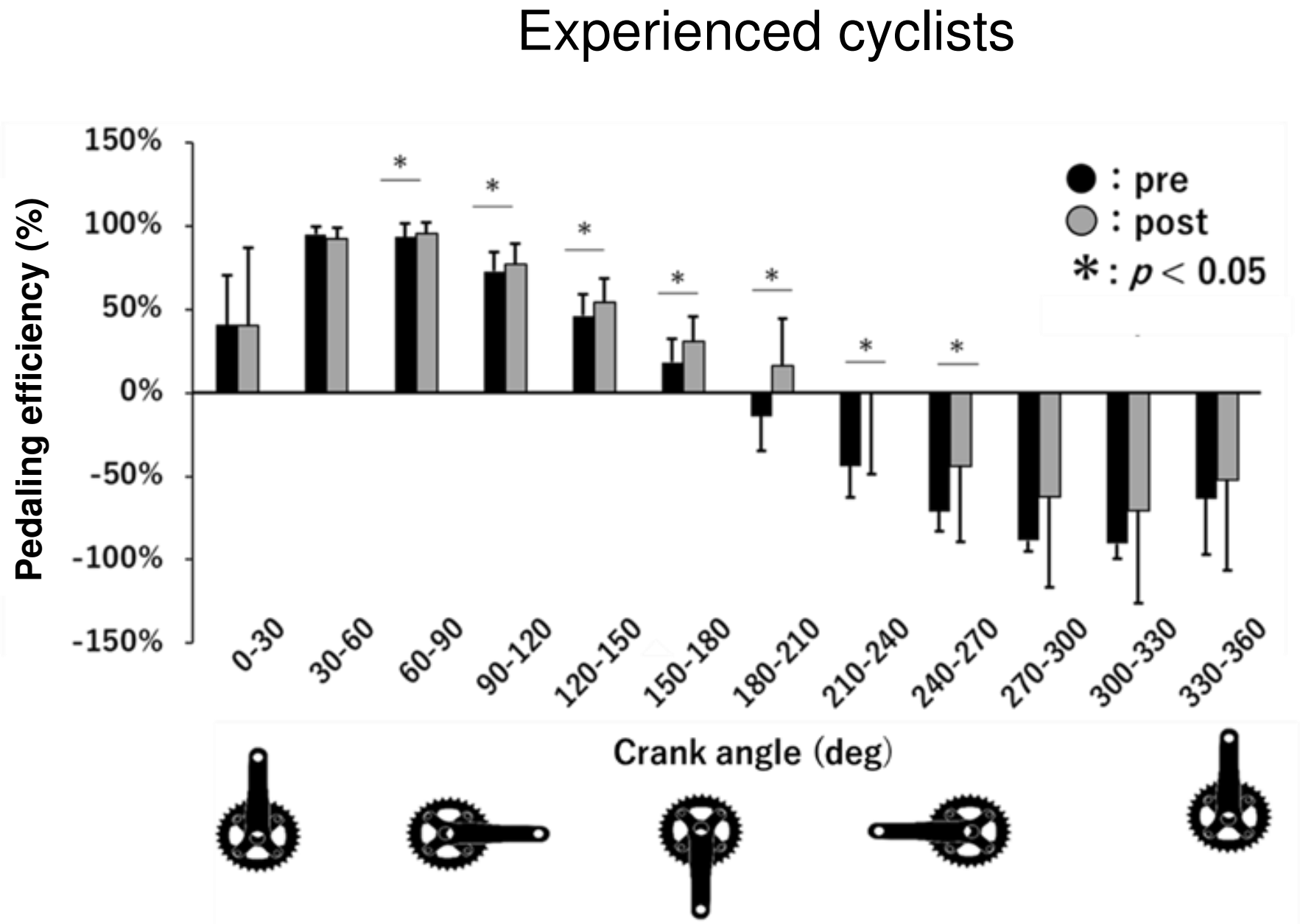
Results: Tangential pedaling force



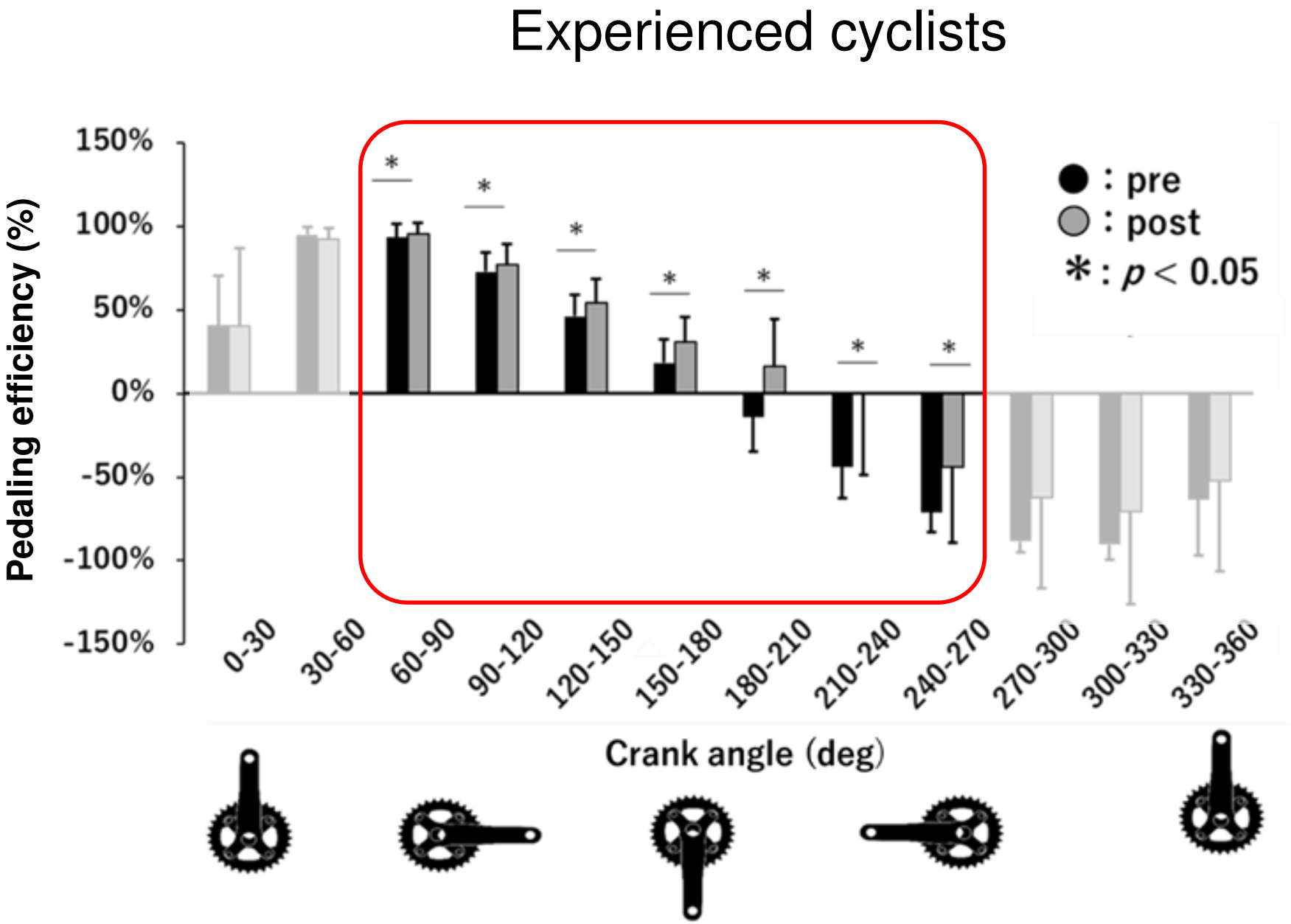
Results: Tangential pedaling force



Results: Pedaling efficiency

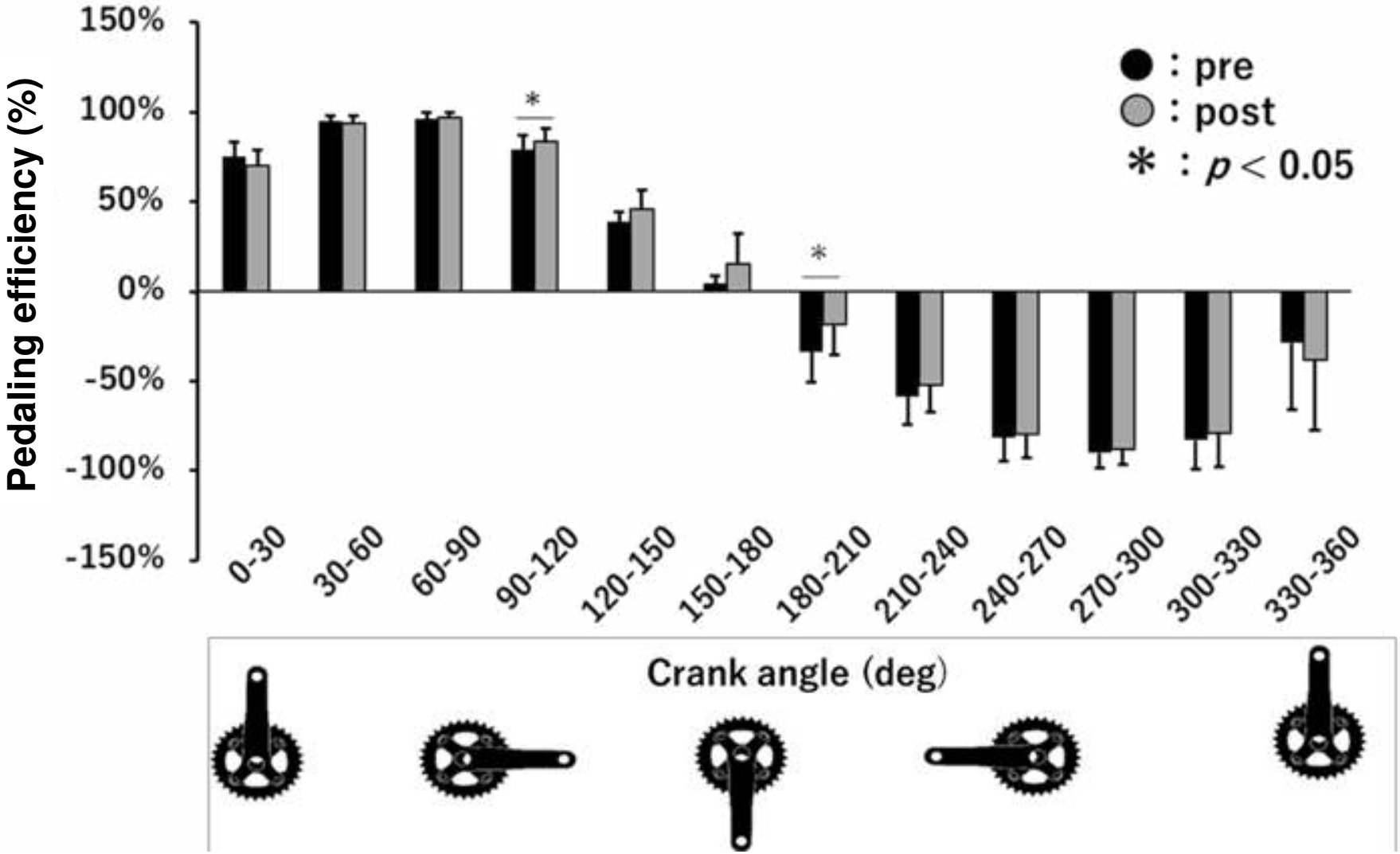


Results: Pedaling efficiency



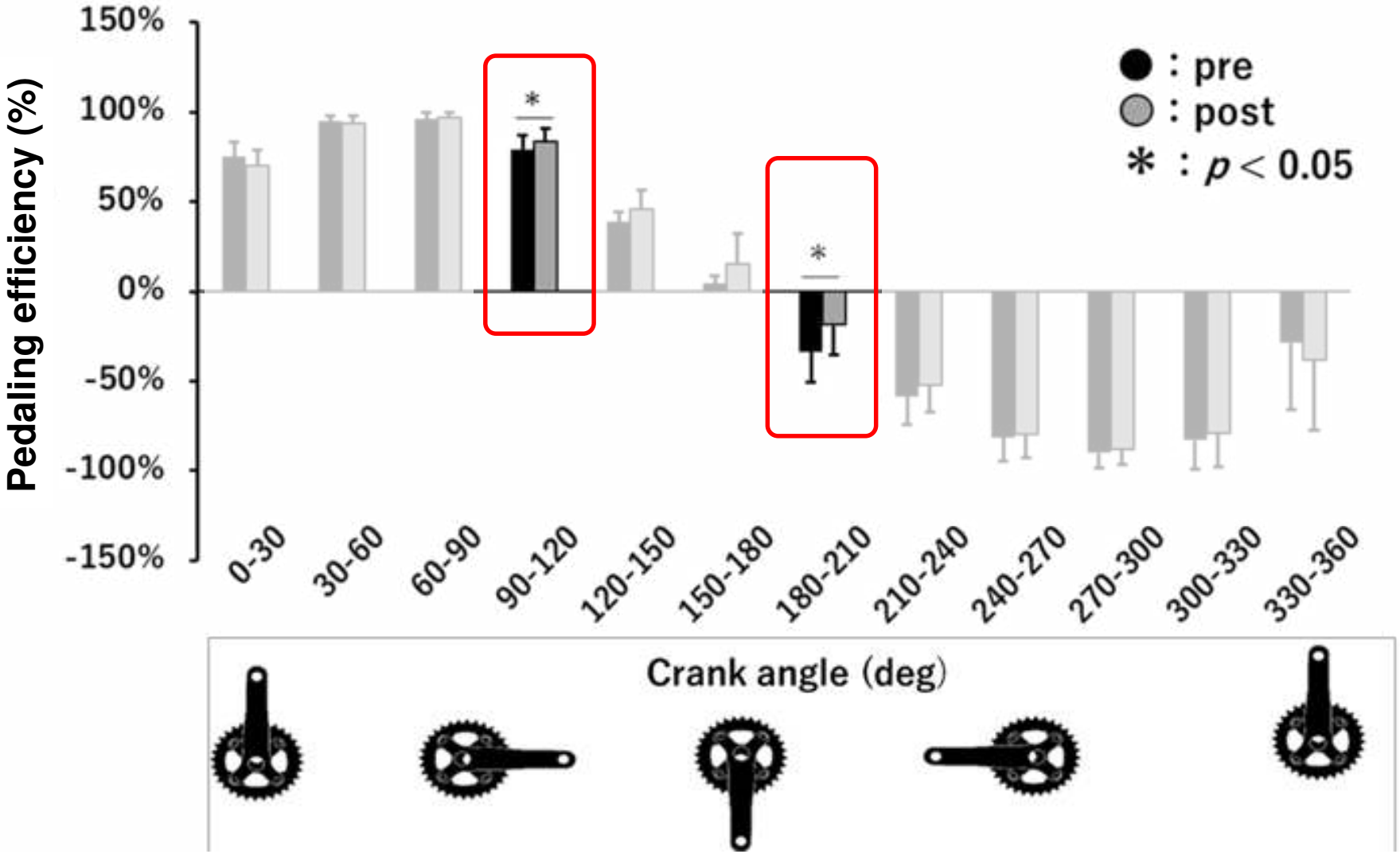
Results: Pedaling efficiency

Inexperienced men

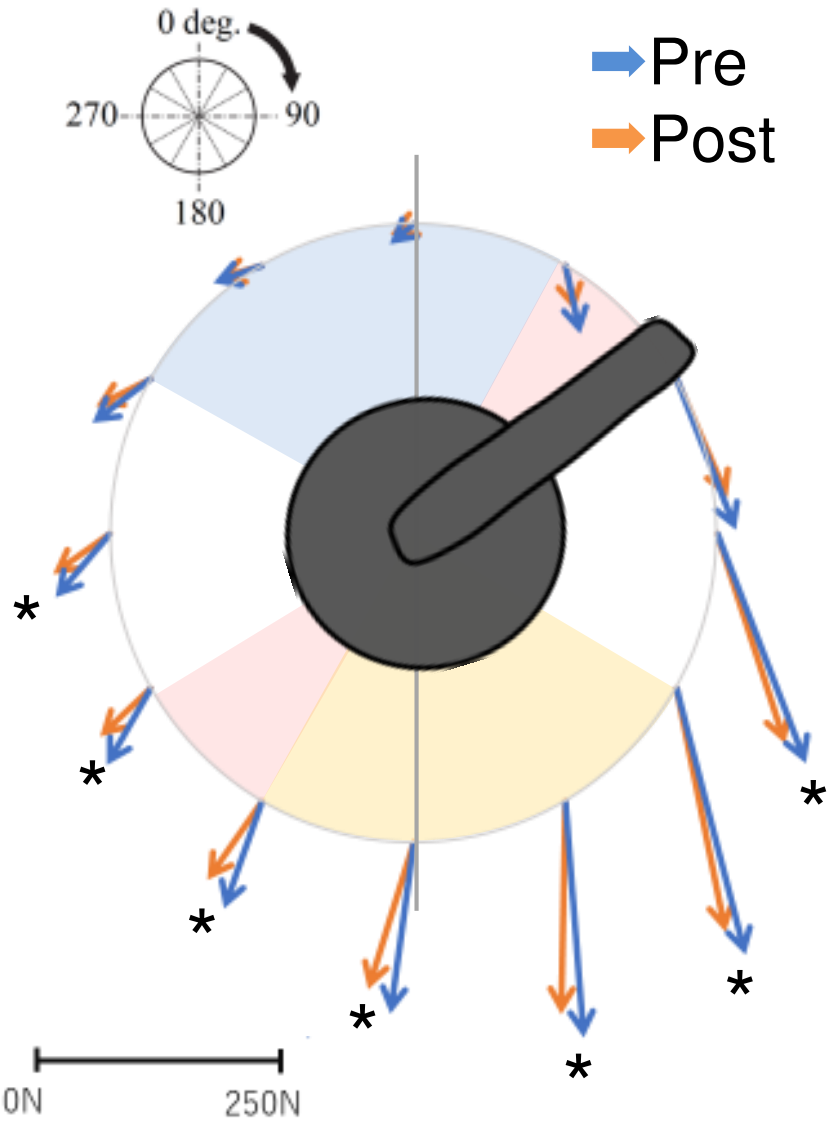


Results: Pedaling efficiency

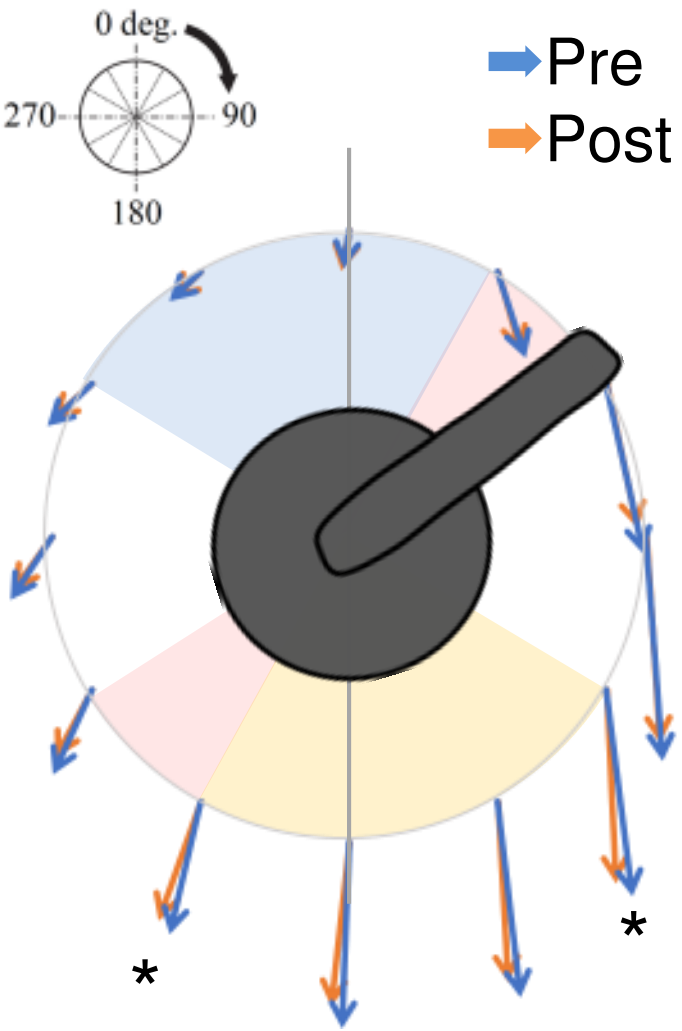
Inexperienced men



Experienced cyclists

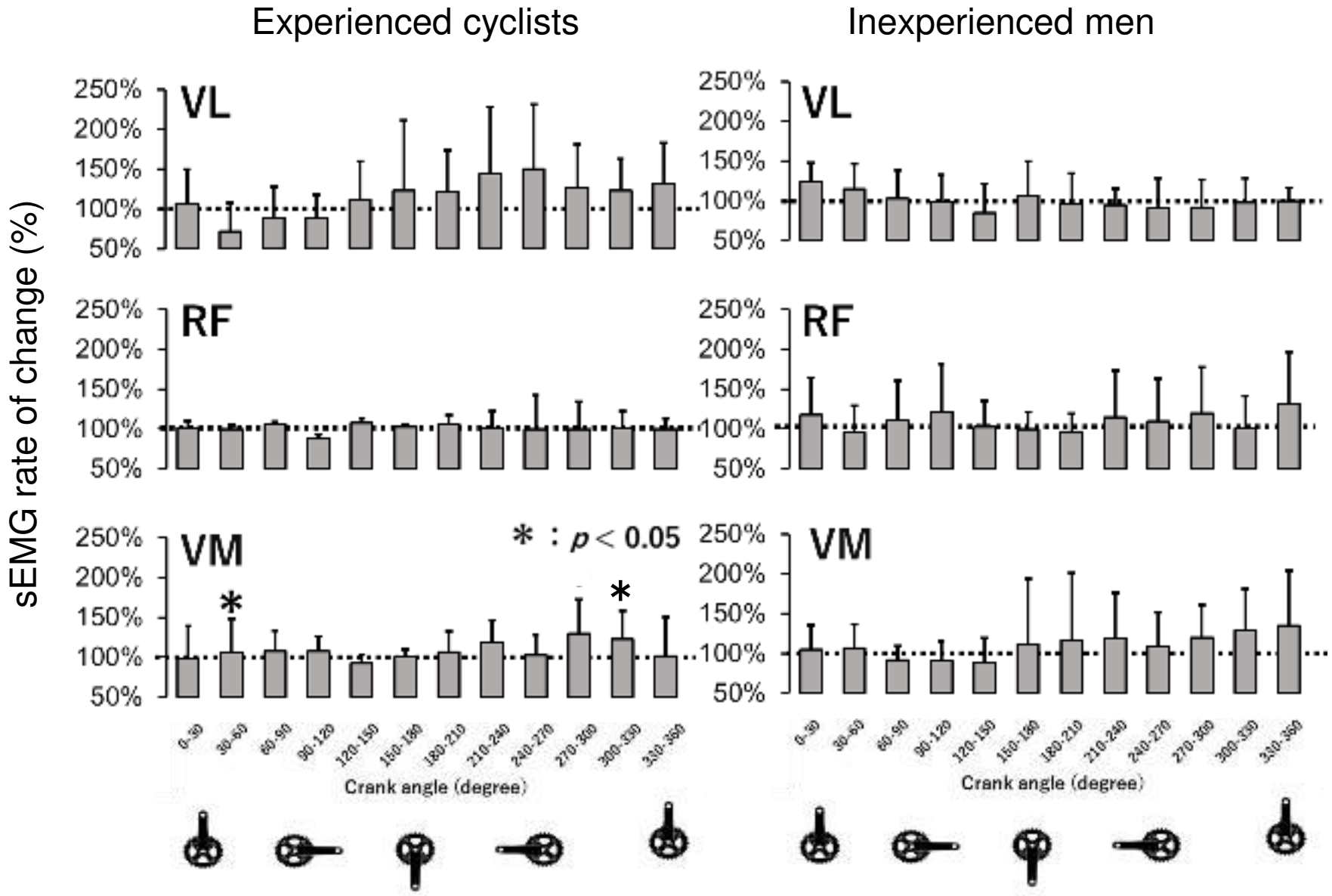


Inexperienced men



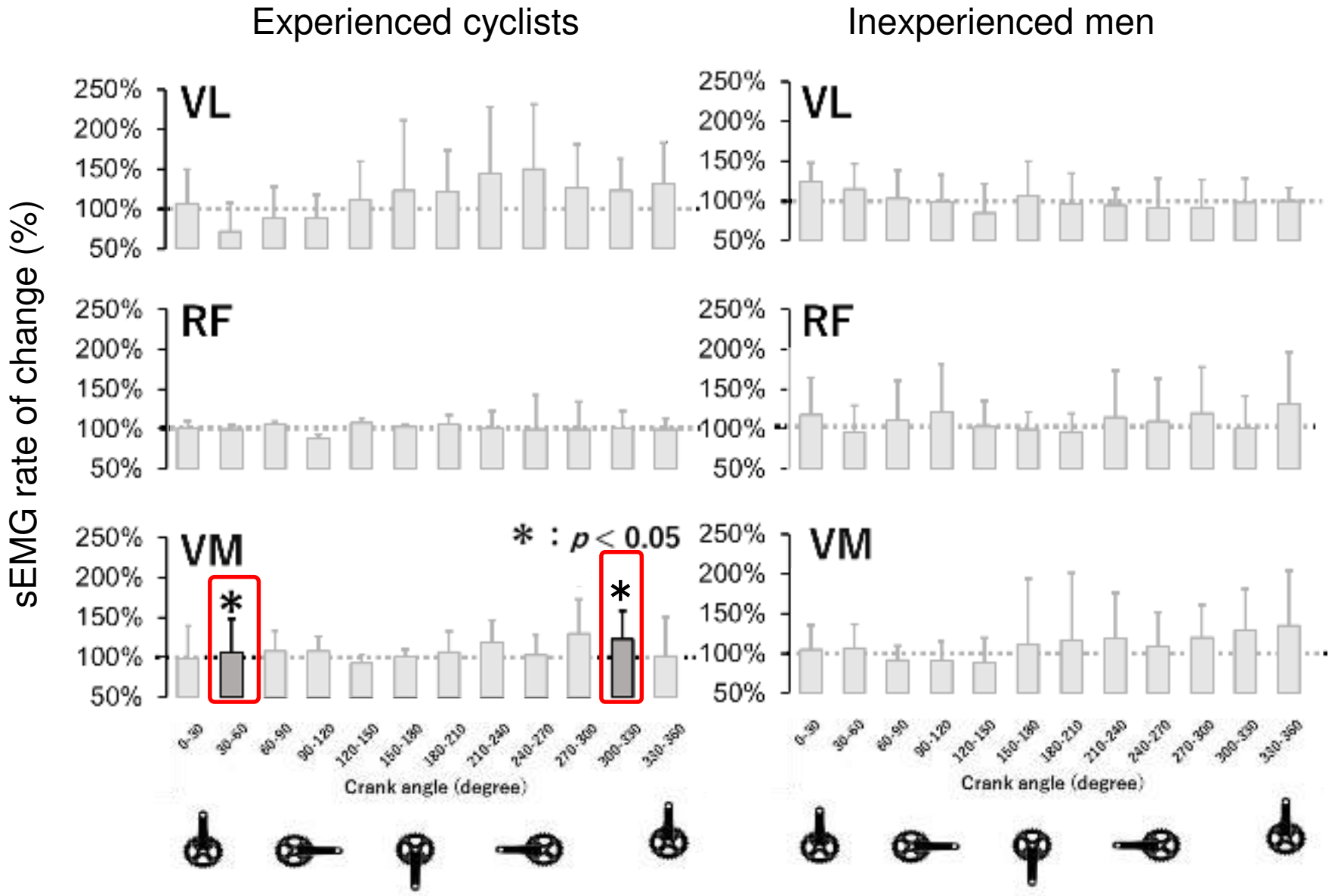
Results: Relative changes of muscle activity

Quadriceps



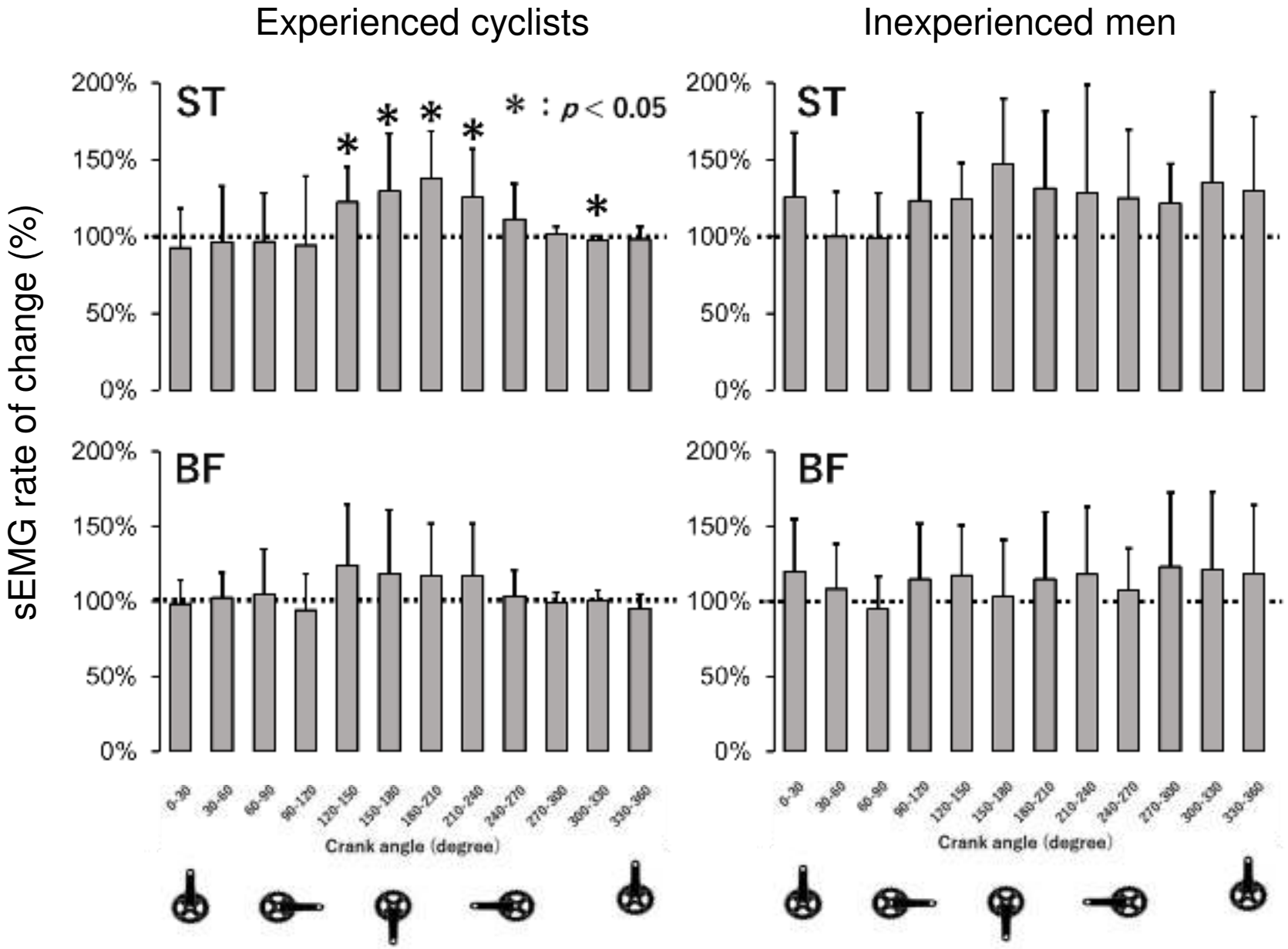
Results: Relative changes of muscle activity

Anterior muscles



Results: Relative changes of muscle activity

Hamstrings



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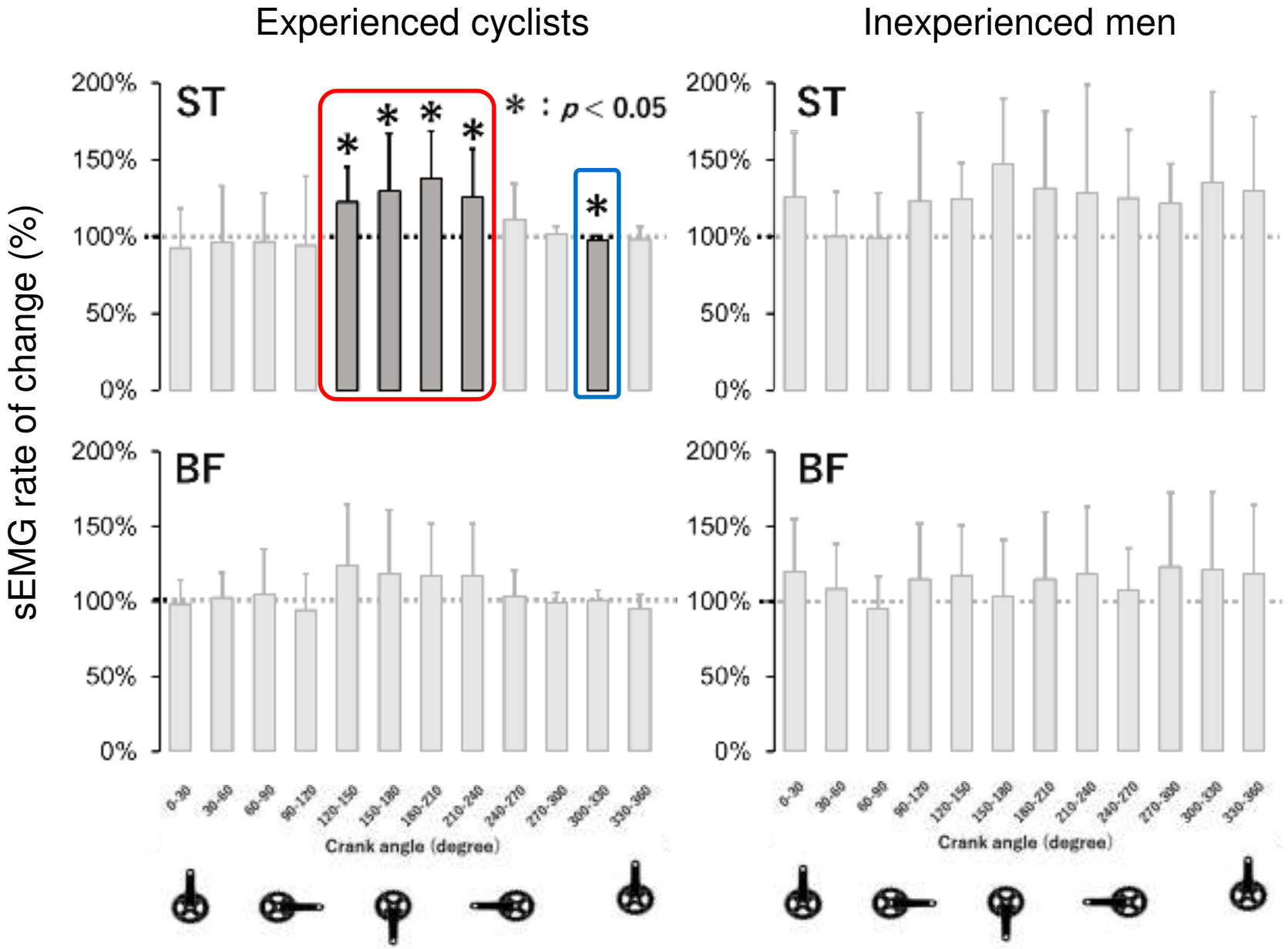
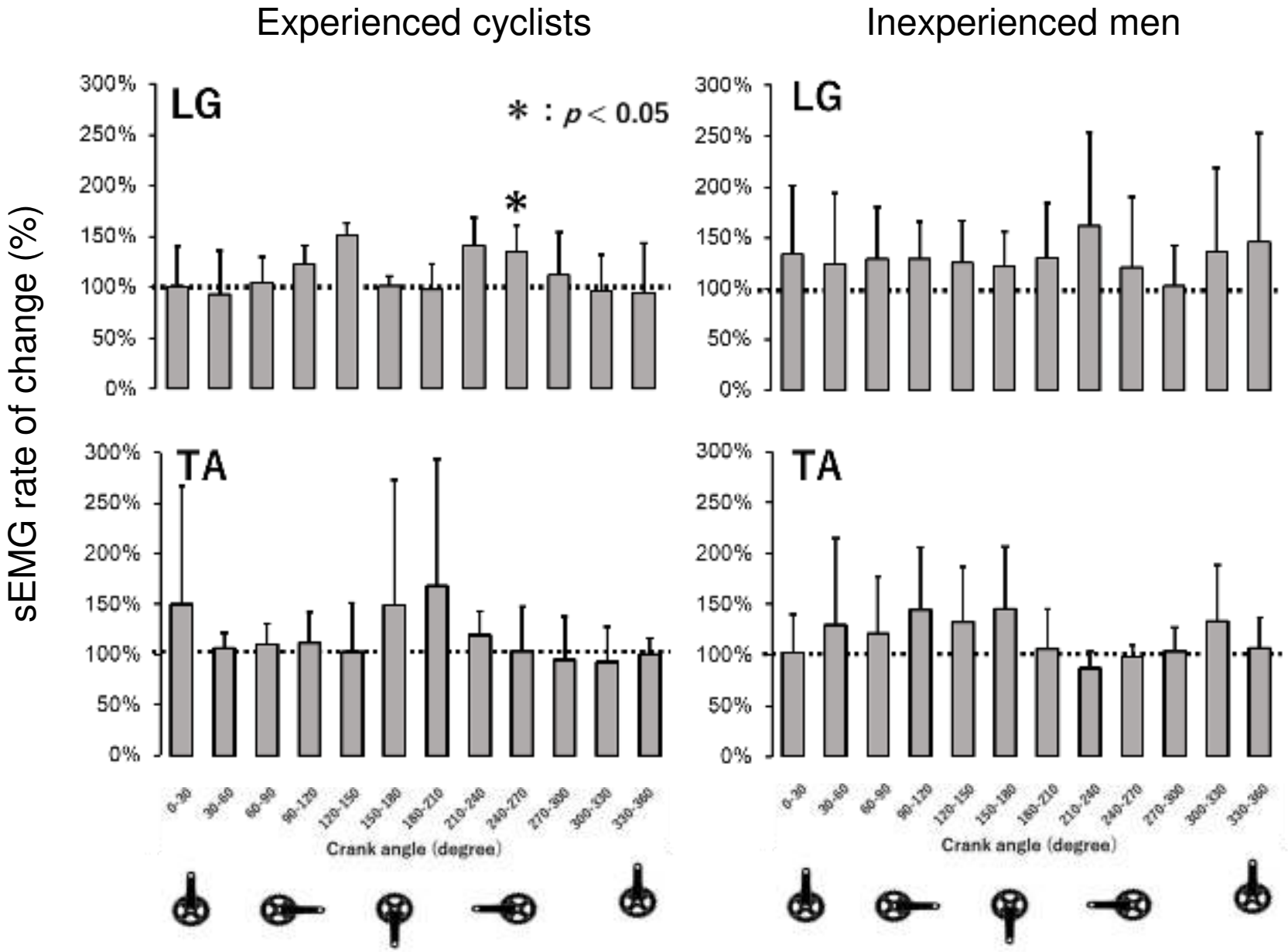


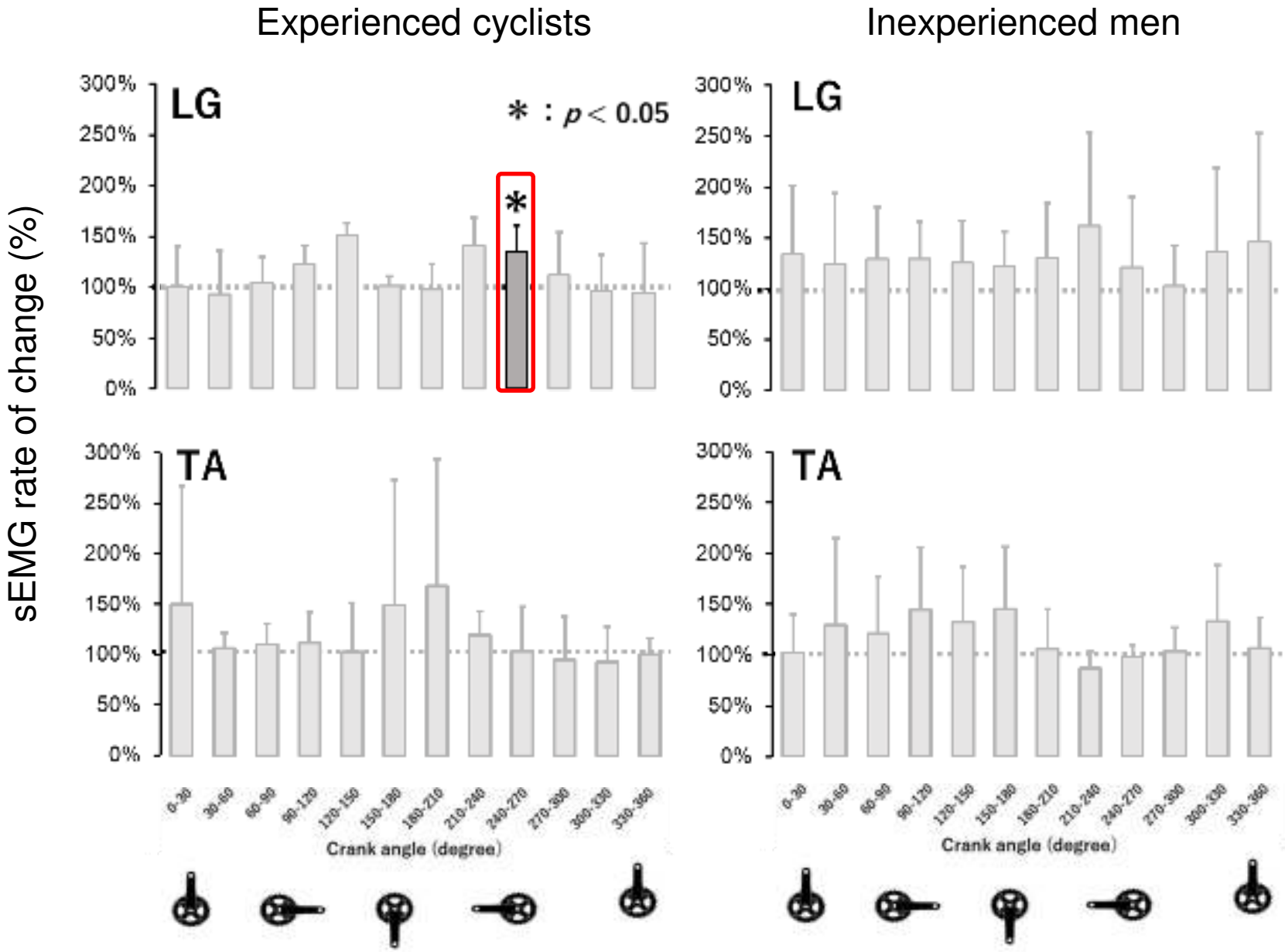
Results: Relative changes of muscle activity

Plantar/Dorsi-flexors



Results: Relative changes of muscle activity

Lower leg muscles

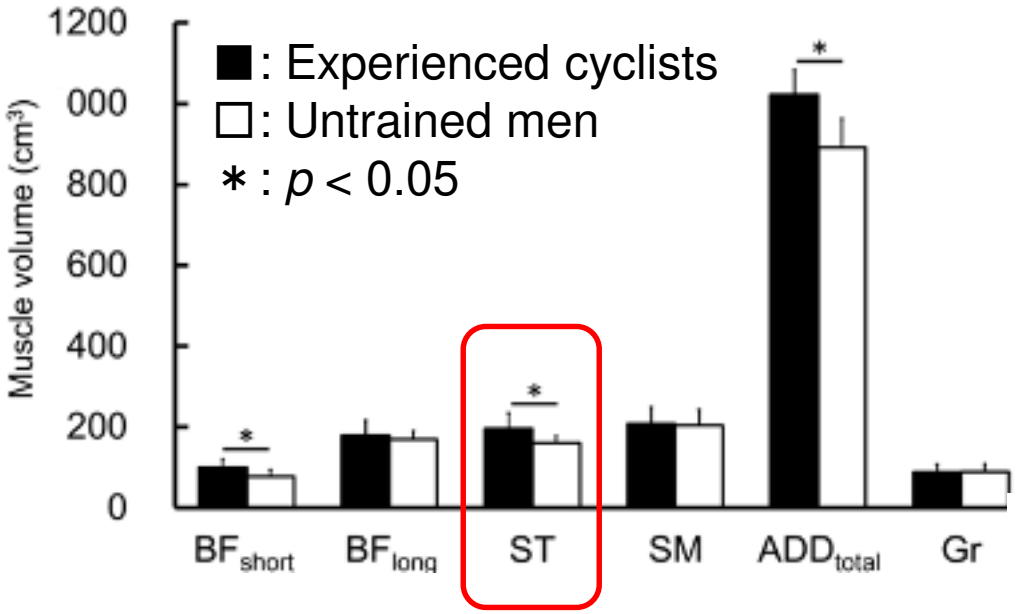


Discussion

✓After intervention, experienced cyclists showed improved pedaling efficiency in the late push and pull back & up phases through:
- Decreased tangential force in the push phase
- Increased tangential force with a marked increase in ST activity in the pull phase

✓A possible increase in the contribution of ST is partially in line with our previous finding of larger ST size in cyclists (Ema et al. 2016).

✓Inexperienced men failed to, or did not show sizable changes in muscle activities although they showed some improvements in pedaling efficiency.



(Ema et al., 2016).

Conclusion

✓ Providing local braking can lead to improvement of the pedaling efficiency.

✓ Experienced cyclists improve pedaling efficiency with higher and smaller muscle activity in the pushing and pulling phases respectively, with an increased activity of the semitendinosus muscle in the pull phase.

✓ The local braking is more effective for experienced cyclists than inexperienced men.

Acknowledgements

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of the Human Performance Laboratory, organization
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Human Performance Laboratory
WASEDA UNIVERSITY