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CHANGES IN MUSCLE ACTIVITY PATTERN IN LOWER LIMB EXTREMITY DURING PEDALLING BY SADDLE HEIGHT

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As a preliminary study for a preferential saddle height for cyclist, muscle activity pattern in lower limb extremity between preferred and higher saddle height during pedalling was compared. Seven cyclists performed 3 min sub-maximal pedalling under two different saddle heights. Range of motion (ROM) of muscle length, onset-timing of muscle activity, and amount of muscle activity in biceps femoris (BF), vastus lateralis (VL), gastrocnemius (GM), and tibialis anterior muscles (TA) were used to compare changes in muscle activity pattern due to saddle height. Results showed that there was a significant difference in ROM of VL and that of TA ($p<.05$), and there was a significant difference in onset-timing of BF and that of GM ($p<.05$). In all muscle, there was no difference in the amount of muscle activity. Further study is necessary to study the effect of various conditions (saddle heights as well as loads and cadences) on muscle activity pattern.

KEY WORDS: pedalling, saddle height, muscle length, muscle activity timing, EMG.

INTRODUCTION: According to the purpose of cycle pedalling, various studies to determine the preferential saddle height have been carried out. Hamley & Thomas (1967) suggested the use of 109% of inseam, which was measured from ischium to the floor, as a saddle height for preferential pedalling (Pruitt & Matheny, 2006). Holmes, Pruitt, & Whalen (1994) recommended the knee angle method using 25~35° of knee angle when the pedal was located at the bottom of the crank as proper saddle height for injury prevention. These two methods may suggest different saddle height. Peveler and Green (2011) compared two methods for determining saddle height based on pedalling economy and anaerobic power. They reported that 25° knee angle by Holmes method showed the best results. However, the controversy for determining preferential saddle height still progresses and further study is needed to understand. It is essential to consider muscle activity pattern when evaluating pedalling performance. In fact, the change of saddle height can directly affect the length and contraction velocity of muscles on the lower limb due to the kinematic change (So et al., 2005; Sanderson & Amoroso, 2009). Therefore, as a preliminary study to suggest preferential saddle height for cyclists, the differences in muscle activity pattern of the lower limb between preferred and higher saddle height were compared in this study.

METHODS: Seven cyclists (Height: 1.76±0.04 m Weight: 83±1 Kg, Age: 34±4 year, Career: 16±8 year) were participated in this experiment. All experiments were performed on developed bike fitting system which can adjust individual frame size for each subject (Bae, Choi, Kang, Seo, & Tack, 2012). For the purpose of this study, every frame size except saddle height was set to subject's own frame size. Saddle height was set to 5% (approximately 3~4cm) higher than preferred saddle height.
For constant load (150W) and cadence (90 RPM) condition, I-Magic trainer (Tacx) was used during pedalling. 3D motion analysis system with 6 infrared cameras was used to acquire motion data, and 4 reflective markers were attached at right anterior superior iliac spine, great trochanter of femur, lateral epicondyle of the knee, and lateral malleolus. To measure muscle activity in vastus lateralis (VL), biceps femoris (BF), gastrocnemius (GM), and tibialis anterior (TA), Trigno wireless EMG systems (Delsys Inc., USA) was used. Motion and EMG

data were synchronized and collected with 120 and 1200 Hz of sampling frequency, respectively.
All subjects were constantly pedalled twice for 3 min, and middle 2 min data was used in the analysis. To remove noise, motion data were filtered using a second-order zero-lag low-pass Butterworth filter with the 10 Hz of cut-off frequency and EMG data were filtered using a 4th-order zero-lag band-pass Butterworth filter with the 15~500 Hz of cut-off frequency.
To compare the effects of saddle height, range of motion of muscle length (ROM), onset timing of concentric and eccentric contraction, and amount of muscle activity (iEMG) were used. To yield ROM and onset timing of concentric and eccentric contraction, muscle length relative to limb segment length was calculated by algorithm suggested by Hawkins and Hull (1990). To calculate an integrated EMG (Σ normalized iEMG) of power phase and recovery phase, full wave rectification, moving averaging per 40 ms and normalization by an individual's maximal muscle activity value were performed (Albertus-Kajee, Tucher & Derman, 2010). To compare the effect of saddle height, paired t-test was performed using SPSS 19.0(SPSS, Inc., USA) with a significant level of .05.

RESULTS: Due to the change in saddle height, there was a significant difference in ROM of VL and that of TA (Table 1), and there was a significant difference in onset-timing of BF and that of GM (Table 1). In all muscle, however, there was no difference in the amount of muscle activity during the power phase and recovery phase (p>.05) (Figure 1).

Table 1: Muscle length and Onset timing

	Range of motion (% segment Length)		Onset timing of concentric contraction (degree)		Onset timing of eccentric contraction (degree)	
	Preferred	Higher	Preferred	Higher	Preferred	Higher
BF	0.061 (-0.002)	0.063 (0.002)	**121.7 * (-7.3)**	**133.1 * (-4.9)**	**295.4 * (-2.4)**	**296.9 * (-2.1)**
VL	**0.106 * (0.01)**	**0.137 * (0.009)**	166.1 (-1.6)	166.9 (-1.1)	337.3 (-10.3)	343 (-7.9)
GM	0.033 (-0.011)	0.034 (0.009)	**101.1 * (-7.4)**	**93.0 * (-4.5)**	303.7 (-11.1)	303.9 (-12.2)
TA	**0.026 * (-0.007)**	**0.033 * (0.007)**	181.3 (-1.9)	177.6 (-3.7)	42.4 (-11.9)	42.4 (-21.8)

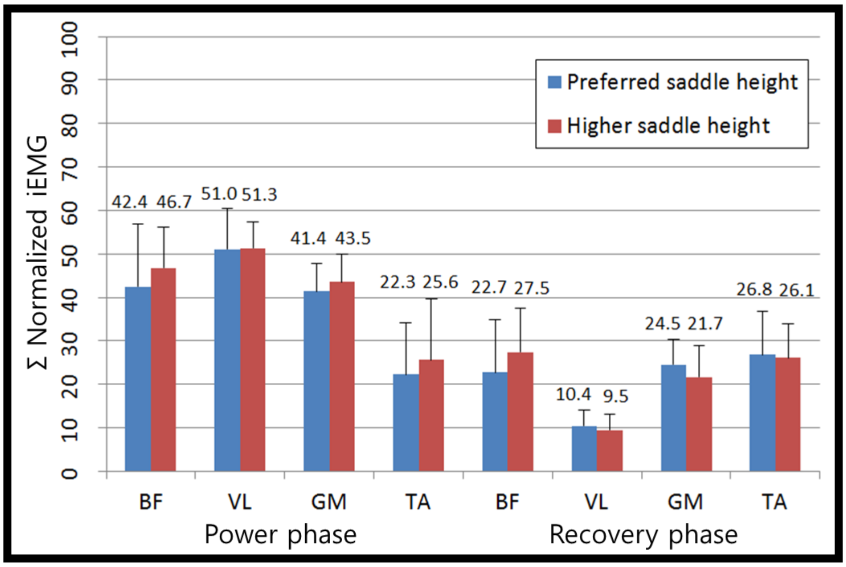

Figure 1: Muscle activities in power and recovery phase due to saddle height

DISCUSSION: During pedalling the change of saddle height can directly affect the length and contraction velocity of muscles by changing the range of motion on the lower limb (So et al., 2005). Muscle activity pattern can be affected by load, cadence, position and strategy of pedalling. In order to consider the effect of saddle heights, all experiment was performed under constant power and cadence condition.

The result of this study was consistent with that of previous study, which eccentric contraction pattern of bi-articular muscles including gastrocnemius and biceps femoris was not related with cadence and closely related to saddle height (Connick & Li, 2012). Sanderson & Amoroso compared mono-articular (soleus) and bi-articular muscle (gastrocnemius) activity pattern by pedaling strategy. They showed that there were significant differences in muscle length and contraction velocity of soleus while no difference in the amount of muscle activity. There was the difference in the onset timing and the amount of muscle activity in gastrocnemius. These results were partially agreed with the results of the present study (Sanderson & Amoroso, 2009).

In general, it is known that the primary role of mono-articular muscle is to produce power during pedalling while bi-articular muscle has a function of controlling the limb properly (i.e. In case of BF, it works like an extensor at the hip joint and a flexor at the knee joint at the same time) like that of antagonist against agonist (So et al., 2005; Raasch et al., 1997).

Based on the results of previous and the present study, it can be concluded as follows. Regardless of the thigh or shank, the change of saddle height can affect ROM of mono-articular muscle and onset-timing of bi-articular muscle. However, there was not any difference in the amount of muscle activity of both muscles by changing saddle height.

CONCLUSION: As a preliminary study for a preferential saddle height for cyclist, muscle activity pattern in lower limb extremity between preferred and higher saddle height during pedalling was compared. There was a significant difference in ROM of VL and that of TA ($p<.05$), and there was a significant difference in onset-timing of BF and that of GM ($p<.05$). In all muscle, there was not any difference in the amount of muscle activity. Further study is necessary to study the effect of various conditions (saddle heights as well as loads and cadences) on muscle activity pattern.

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