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PHYSIOLOGICAL AND ELECTROMYOGRAPHIC RESPONSES AT THREE LEVELS OF BICYCLE SEAT HEIGHT

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Recently, bicycle riding has become one of the most popular exercises. As the use time increased, the risk of pedalling injury raised. Holmes (1994) indicated that inappropriate bicycle saddle height could result in lower limbs injuries. The motivation of this study was to find out the best riding position that could effectively use energy from the physiology and electromyography measures. The oxygen consumption (VO_2), heart rate (HR), respiratory exchange ratio (RER) and the muscle activity (electromyography, EMG) from rectus femoris (RF) and biceps femoris (BF) of lower limb were collected during a 6 min cycling trail in three different heights of bicycle saddle. The purpose of this study was to compare the effects of three different types of bicycle seat heights and different perspectives of muscle activity and physiology's parameters.

KEY WORDS: EMG, VO_2, Heart Rate, Bicycle

INTRODUCTION: Unlike other exercise involving multiple skills, bicycle riding is more standardized since the bicycle constrains lower limbs movements. For instance, bicycle riding is suggested that cycling might be a useful exercise in the rehabilitation of patients with injuries of the anterior cruciate ligament, medial collateral ligament of the knee or achilles tendon because of the standard pedalling trait. (Ericson, Bratt et al. 1986) Therefore, having a thorough understanding of muscles activities of lower limbs during pedalling is the most important matter in order to improve rehabilitation protocols and racing performance. The information that required to be understood is the pedalling movement including identifying the lower limb muscles which are activated and precisely knowing their level of activation. An efficiency riding position is vital for an athlete who pursues a better performance.

In the past, many studies have showed inconsistent results with muscle activities at different seat heights. Morgan (2009) indicated that riding bicycle with an inappropriate seat height might result in bad consequence. Jorge and Hull (1986) presented that an increasing level of muscle activities for quadriceps (vastus lateralis, rectus femoris, vastus medialis) and hamstrings (biceps femoris, semimembranosus) when the saddle was lowered to 95% of leg length. However, Ericson (1986) showed that the changes in different saddle heights would not affect the changes of quadriceps (rectus femoris, vastus medialis).

In addition, most of the energy in the body is produced aerobically. VO_2 measures can be used to presume how much energy a subject is expending. HR is also used to help the physician making suitable tendency of rehabilitation protocol. Respiratory Exchange Ratio (RER) is also a physiological parameter which presents the ratio of carbon dioxide production and oxygen consumption of metabolic to monitor activity intensities. Hence, we investigated the relationships between electromyography and physiological parameters during the pedalling at different seat heights and this might provide further information to bicycle riders. Therefore, the purpose of this study was to compare the effects of electromyographic and physiological variables at three different bicycle seat heights. We hypothesized that the higher muscle activities would occur at a lower seat position and the lowest VO_2, lowest HR, lowest RER would occur at the middle seat position than others.

METHODS: Ten healthy males with regular exercise habits (age: 24±5; Height: 171.3±2.8; Weight: 67.5±3.9) were recruited for this study. None of them had lower extremity injuries within 6 months prior to the experiment.
The muscles that considered were the rectus femoris (RF) and biceps femoris (BF) of the dominant limb (kicking limb). Pre-amplifiered wireless surface electrodes (DELSYS, Trigno Wireless EMG System, USA) were used to pick up electromyogram potentials simultaneously during cycling tests. Electrode placement was determined as described by Hermens et al., 2000. Before attaching the electrodes, the skin was rubbed with wet cloth to remove dead skin layer, and cleaned with alcohol. To reduce skin movement artifact between electrode and skin, the electrodes were taped to skin with adhesive tapes.
On the other hand, from the physiology aspect, participants wore masks and the portable cardiopulmonary exercise system in order to collect the respiratory gas. The respiratory gases were recorded and analyzed by CORTEX metabolic system (MetaMax 3B, CORTEX, Germany) during the whole cycling. Heart rates (HR) during pedalling were collected by using Polar electro monitor (Polar S810iTM, Polar Elector Inc, Finland).
Each participant needed to ride on the bicycle ergometer (H/p/cosmos, Cyclus 2, Germany) at 60rpm with a power output of 150W at three different seat heights for the experiment. Subjects were asked to ride 6 minutes at each seat height. In this study, we used the Holmes Method (1994) to classify three levels of saddle height. It depends on the angle of the knee joint flexion at the bottom of the pedal stroke. We set the middle seat level at the angle of 25°, higher seat level at the angle of 10° and lower seat level at the angle of 40°. Before the experiment trial began, all subjects were asked for 5-min warm up at 60rpm at a power output of 50W. The sequences of different heights were randomized to avoid the experiment bias.
EMG data were collected for 30 seconds from 3 minutes to 3 minutes, 30 seconds of each 6-min cycling trial. Raw EMG signals were bandpass by 20-480 Hz and root mean square (RMS) with 30 ms windows as followed. Individual cycles were isolated using the crank potentiometer top dead center (TDC) indicator and then averaged to obtain a single EMG pattern for each muscle in each subject. Mean EMG values were selected 10 cycles from the 30-second signals. Mean EMG data were then normalized by the peak value for each muscle. Crank position data were collected for synchronization of EMG signals and cycling kinematics. All EMG data were analyzed by using Matlab (Mathworks Inc., USA). A one-way ANOVA was employed for the comparison of the EMG, VO_2, HR, RER among the 40°, 25° and 10° of knee flexion angles. The level of statistical significance for all analysis was set at $\alpha=0.05$.

RESULTS: There were no significant differences on muscle activations among three different seat heights (Table 1). In addition, we found that VO_2 at the higher seat position had a significant higher level than at the lowest seat position (*p<0.05*); otherwise, HR from the lower seat position was significantly higher than from the middle seat position. There was also no significant difference in RER throughout the trial.

Table 1
Normalized mean (SD) EMG data of rectus femoris (RF) and biceps femoris (BF) during three different seat height pedalling.

Level of seat height	RF(%)		BF(%)	
	Mean	SD	Mean	SD
High position	23.9	7.4	21.5	7.0
Middle position	23.9	6.2	18.9	6.6
Low position	22.0	5.1	18.0	5.4

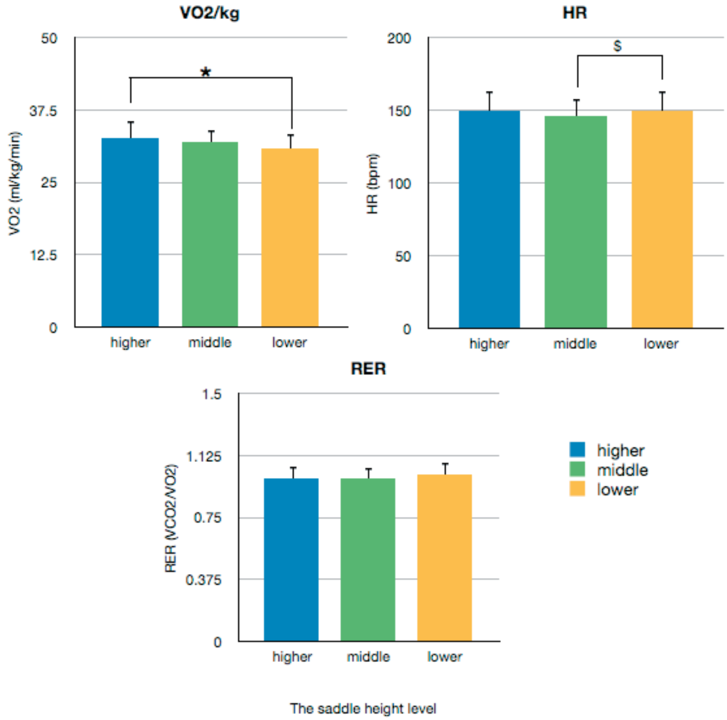

Figure 1: Mean (SD) of VO_2, HR and RER profiles during three different seat height conditions. *Significant difference between higher and lower seat height at VO_2/kg($p < 0.05$). $ Significant difference between middle and lower seat height at HR ($p < 0.05$).

DISCUSSION: Previous studies have mentioned that we can use muscle activations and oxygen consumptions to detect the most appropriate saddle height during cycling. It was recommended that saddle height set between 25° to 35° knee flexion angle for both trained and untrained cyclists could increase performance and to prevent injuries (Peveler, Pounders et al., 2007). However, the results of the current study showed different outcomes.

In the current study, while pedalling at the high saddle position, the value of consuming VO_2 was significant higher than the low saddle position. This result indicated that pedalling at higher position required more energy consumption. A plausible explanation is that higher seat position produced more body sway which could consume more energy while pedalling.

The HR of lower seat height (149.78±13.78 bpm) was significant higher than the middle seat height (146.09±12.17 bpm). Generally speaking, heart rate is related to exercise intensity. According to Wells (1957), it was classified that heart rate ranged 140-160 bpm to middle intensity of exercise. In spite of significant difference exited between middle seat height and lower seat height, their exercise intensity was at the same range.

In this study, our results indicated that EMG signals were not significantly different among three levels of seat height while riding bikes. Only trend were founded from the experiment. Both of RF and BF had the least muscle activation at the lowest riding position. Because lower riding position made subjects to maintain knee flexion passively during pedalling, BF did not require actively contracting to maintain knee flexion. It resulted in low activation level of BF at the lower saddle position. The function of RF is to make knee extension and hip flexion. While riding at the lower saddle position, constant knee flexion angles caused RF had the least muscle activation. Since the knee was never fully extended while riding at the lower saddle position, it could limit knee extension function and resulted in both low profile muscle activation of RF and BF.

CONCLUSION: According to the current study, bicycle seat height could have little relationship to the lower extremity muscle activations. The results of oxygen consumption could suggest that riding bicycle at low or middle saddle height would likely avoid energy wasted and be more effective in energy consumption.

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