EMG Pattern of Lower Extremity Muscle for iSAAC a New Resistance Training Machine

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Abstract: Many researchers have investigated muscle contraction, often focusing on eccentric contraction. However, some studies have revealed that concentric-only training contributes to increased concentric strength. Moreover, eccentric contraction induces more muscle damage than concentric contraction. Even though there is great demand for eccentric contraction in practice, concentric contraction is essential for an athlete's performance. To focus on concentric contraction exercise, we developed a concentric-only exercise machine designated Intelligent System of Advanced Actuation for Concentric Training (iSAAC). In this study, we compared the EMG patterns of squat (SQT), seated leg press (LP), and iSAAC. We observed a unique EMG pattern and the generation of explosive power during knee extension with iSAAC. Therefore, iSAAC enables athletes to enhance the concentric strength of their lower extremity muscles.

1 OBJECTIVES

Resistance training is essential to improve the performance of athletes. Recent studies have shown the effects of concentric and eccentric contraction. Some researchers reported that eccentric contraction induces greater muscle hypertrophy than concentric contraction. However, it also causes greater muscle damage than concentric contraction (Seger et al., 1998). Concentric-only exercise causes a greater increase in concentric strength than eccentric-only exercise (Blazevich et al., 2007). Moreover, concentric isokinetic training improves jumping performance (Kovačević et al., 2013). Therefore, concentric training is necessary for athletes to improve their concentric strength and power. In order to induce these concentric training effects, we developed a concentric-only exercise machine designated Intelligent System of Advanced Actuation for Concentric Training (iSAAC).

The purpose of this study is to use surface EMG for comparing lower extremity muscle activity during iSAAC, back squat (SQT), and seated leg press (LP). We selected these exercises because they generate similar movements of the lower extremities.

2 METHODS

2.1 Subjects

Five male college students participated in this experiment. Their age, height, and mass were 21.2 ± 0.4 years, 171.2 ± 6.2 cm, and 65.0 ± 7.3 kg, respectively.

2.2 Details about iSAAC

iSAAC provides cyclic concentric-only training of the lower extremities. iSAAC adopts braking force as resistance load. Because braking force is less than or equal to human generated force, iSAAC is a safe training machine. The timing of applying resistance is determined by knee joint angle that is measured by goniometer. Therefore, the iSAAC generates

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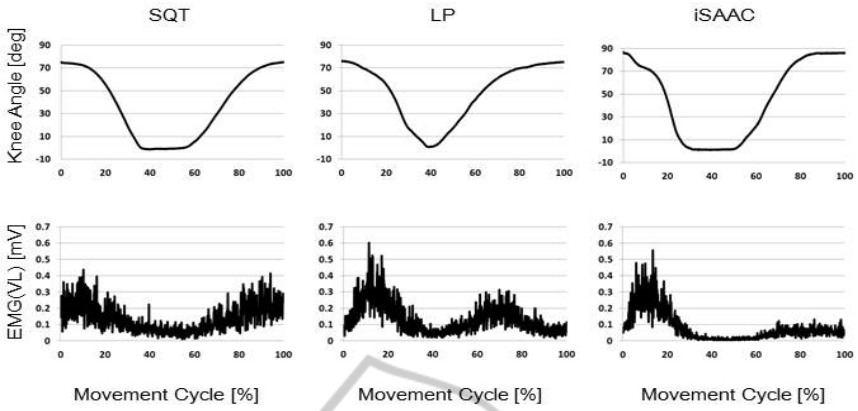

Figure 2: EMG patterns of vastus lateraris muscle (VL) during a motion of SQT, LP, and iSAAC (one subject). All other muscles display similar EMG patterns in each exercise. When the knee is extended, the knee joint angle is 0°.

training resistance only while subjects extended their hip and knee joints. This machine is also able to calculate the joint torque using sensory information. In addition, the resistance during exercise could be varied by control inputs from PC.

2.3 Procedures

Before the execution of the experimental tasks, all subjects performed 1RM of LP, SQT, and iSAAC. The value of each 1RM was determined by gradually increasing the mass of the weight until the participants thought that they were able to lift no more than three repetitions. After 3 min of recovery, they continued lifting until they were unable to lift the weight; then, we calculated their 1RM by using a 1RM prediction equation (Baechle et al., 2000).

During the experiment, subjects performed eight repetitions with 70% of their 1RM for each exercise. Each exercise was performed twice by all subjects. While subjects were performing the exercise, we measured the muscle activity of rectus femoris, vastus lateralis, vastus medialis, biceps femoris, gluteus maximus, and joint angle of the knee. Muscle activity was measured using wireless surface electrodes. The data were collected using Vital Recorder. Knee joint angle was measured by using a goniometer. When the knee was fully extended, the knee joint angle was 0°. The data were collected by Powerlab and Labchart. The sampling rates of surface electrodes and goniometer were 1 kHz.

2.4 Data Analysis

We analyzed EMG data using KineAnalyzer. EMG data were rectified after a filtering process. The data included one motion of each exercise and one motion consisting of ascent and descent phases. The measured data for each subject were normalized to their movement cycle and averaged.

3 RESULTS

The averaged EMG of vastus lateralis muscle and knee joint angle in each exercise are shown in Figure 2. Five measured muscle displayed similar EMG patterns in each exercise. However, these three exercises display unique EMG patterns. In SQT, all muscles contracted throughout the motion. On the other hand, LP and iSAAC displayed peaks during knee extension. The difference between LP and iSAAC is that LP displayed another peak during the descent phase. In iSAAC, all muscles tended to reach one large peak in the beginning. In addition, there was no remarkable muscle activity during the descent phase in iSAAC. This result showed that these muscles had almost no eccentric contraction in iSAAC.

4 DISCUSSION

According to the EMG data, LP and SQT featured muscle activity in both eccentric and concentric phases. On the other hand, iSAAC featured a brief period of muscle activity in the concentric phase. Because iSAAC training required the generation of explosive concentric power, this training machine is suitable for sports that requires explosive power such as football, rugby, and wrestling. Although iSAAC is a squat-like exercise, result indicates differences between iSAAC and squat. Further studies are required to quantitatively analyze muscle

activity with iSAAC and to investigate the short- and long-term training effects of iSAAC.

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REFERENCES

Baechle, T. R., Earle, R.W., 2000. *Essentials of strength training and conditioning*, Human Kinetics, Champaign, IL, 2nd edition.

Blazevich, A. J., et al., 2007. "Influence of concentric and eccentric resistance training on architectural adaptation in human quadriceps muscles." *J Appl Physiol* 103(5): 1565-1575.

Seger, J. Y., et al., 1998. "Specific effects of eccentric and concentric training on muscle strength and morphology in humans." *Eur J Appl Physiol Occup Physiol* 79(1): 49-57.

Kovačević, Erol, et al., 2013 "The effects of concentric isokinetic training on jumping performance." Homo Sporticus 15.2: 29-34.