Effects of cold stimulation of the skin on strength gain during lower intensity isometric training

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Introduction
An increase in muscle strength largely depends on the activity of high threshold motor units (HT-MUs). Therefore, to increase muscle strength, training of HT-MUs with high muscle output is necessary. An effective isometric training regime would use maximal contractions and increase the production of contraction duration x number of contractions. In general, marked strength gain is achieved by high-intensity training, but only slight strength gain by low-intensity training. Recently, low intensity occluded resistance training has been shown to be effective at increasing muscle strength and inducing hypertrophy. However, there are few studies on strength gain with low-intensity. If HT-MUs with high output are recruited during training at low-intensity and of a short contraction duration, it may have similar effects to MVC training. We have demonstrated that the decrease in skin temperature more markedly acted on HT-MUs than on low threshold motor units (LT-MUs), resulting in a decrease in the threshold force of HT-MUs. The purpose of this study was to evaluate the effects of lower intensity muscle strength training with cold stimulation.

Methods
The subjects who volunteered for this study were five healthy males, and the training used the elbow flexor muscle group. Training intensity used 30%MVC (T30) and 10%MVC (T10) with skin cold stimulation conditions at 25°C. The training limbs were randomly determined. In the case of T30, training was performed with 50 repetitions at 30%MVC target force for 3sec isometric contractions at rest for 3sec. In the case of T10, training was performed with 50 repetitions at 10%MVC target force for 9sec isometric contractions at rest for 3sec. Before the initiation of training, the skin temperature was cooled to 25°C by cooling for 2 minutes using the apparatus. The training period was 6 weeks, and maximum strength were collected pre-training, after 3-weeks, and after 6-weeks. The intensity was adjusted to the target force using an X-Y recorder. Muscle activity (EMG activity) was detected from the brachial biceps caput breve (BCB) by bipolar lead (interelectrode distance, 10 mm) using a surface electrode (5 mm in diameter). Surface EMG signals were A/D converted at a sampling frequency of 1,000 Hz using an analysis system, and the integrated EMG (IEMG) and mean power frequency (MPF) were calculated.

Results
IEMG increased during the 50 contractions with or without skin cold stimulation at T30 and T10. However, with skin cold stimulation IEMG increased in the latter half of the contractions more than without skin cold stimulation at both loads. The muscle activity to maintain 30% and 10%MVC increased significantly during contractions with skin cold stimulation. On the other hand, MPF did not show any significant change during the 50 contractions with or without skin cold stimulation at both loads. After training for 6 weeks, maximum strength and IEMG increased significantly at T30 (113.7±8.4% and 119.6±13.4%, respectively) and T10 (110.1±6.8% and 122.4±13.5%, respectively). There were not showed any significant changes between T30 and T10. However, after training for 3 weeks, maximum strength and IEMG did not change significantly at only T10 (P>0.05). On the other hand, maximum strength and IEMG increased significantly at T30 (105.3±5.9% and 117.6±12.5%). MPF did not change significantly at T30 and T10 after 3 and 6 weeks.

Discussion/Conclusion
It can be concluded that maximum muscle strength was increased by skin cold stimulation, even after training at a lower intensity. The gains in strength of training using MVC range from 0.4 to 1.1% per day as a percentage increase per training day. In the present study, maximum muscle strength increased by 13.7% (0.57%/day) and 10.1% (0.42%/day) after 30% and 10%MVC training for 6 weeks. The decrease in skin temperature with skin cold stimulation more markedly acted on HT-MUs than on low threshold motor units (LT-MUs), resulting in a decrease in the threshold force of HT-MUs. The results in the onset of muscular fatigue with skin cold stimulation shows to be compensated for by enhanced activation of the higher threshold MUs in an effort to maintain force output. These results suggest that training with skin cold stimulation may induce the participation of HT-MUs at lower intensity. The training intensity used in this study was equal to the level of routine daily life activities. Therefore, the recovery in-patients with decreased HT-MUs activity due to injury, or aged people with decreased function would benefit from a low intensity resistant training program.

References