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Effect of Different Intervention Methods on Recovery of Exercise-Induced Muscle Fatigue

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ABSTRACT

The aim of this study is to study the effects and differences of different recovery methods such as passive break (PB), active break (AB), and vibration break (VB) on muscle performance recovery after muscle fatigue. The biceps brachii (BBM), which is prone to fatigue during exercise, was taken as the object to study. 10 healthy males were recruited to conduct the experiment. After the experiment, One-Way Repeated Measures ANOVA was used to compare the difference of muscle performance index (MVC, RMS, MF) between groups (PB, AB, VB) at different time points (pre-fatigue, post-fatigue, and post-recovery). JASA method was also used to analyze the muscle recovery effect. Results show 1-minute AB is more effective for muscle fatigue recovery between exercise sets than 1-minute VB.

Keywords: Recovery method, Muscle fatigue, Vibration, Stretch, EMG

BACKGROUND

Exercise has considerable physical and mental health benefits, but excessive exercise may cause physical fatigue. Especially muscle fatigue after continuous muscle contraction, which will reduce subsequent sports performance and cause muscle injuries. Therefore, if effective recovery methods can be used in a limited time after muscle fatigue, sports performance will be enhanced again and possible sports injuries will be also reduced.

In the past, fatigue recovery has mostly been passive rest, which is simple and least restrictive, but the recovery effect is less advantageous compared to another active rest. For example, previous studies have found that performing mild centripetal contractions in the presence of muscle injury can increase blood flow fivefold, accelerate oxygen delivery to damaged muscles (Robergs et al. 1997), and accelerate the elimination of tissue fluid accumulation in swollen muscles (Mohr, Akers and Wessman, 1987), thus enhancing recovery efficiency (Clemente et al. 1991), but the effect of active recovery may vary depending on the approach and lasting time (Zhang, Wang and Ye, 2014), so the results are inconclusive.

The recent emergence of vibration relaxation can bring similar effects like active recovery without active muscle contraction, such as increased local

blood flow (Menéndez, 2015), and improved strength performance (Zhang et al. 2014), which are better for muscle fatigue recovery.

Therefore, the aim of this study is to study the effects and differences of different recovery methods such as passive break (PB), active break (AB), and vibration break (VB) on muscle performance recovery after muscle fatigue. The biceps brachii (BBM), which is prone to fatigue during exercise, was taken as the object to study.

MATERIALS AND METHODS

Participants

Ten healthy male college students (non-athletic majors or athletic students) were recruited in accordance with the following inclusion criteria: (1) No muscular or skeletal injuries to the upper limbs within the last six months, (2) Not using medications for muscle relaxation within the last six months, (3) No cardiovascular disease, hypertension or related visceral disease and acceptable for maximal exercise testing.

Procedures

Ten subjects took part in the experiment three times every other week. No caffeine, creatine, branched-chain amino acids or alcohol should be consumed prior to the test; no other strenuous upper limbs exercise or muscle damage or soreness should be involved in the week of the test; each measurement should be taken at the same time of the day and the test should be done indoors (room temperature approximately 23°C); no subject should have a cold or fever on the day of the test.

The same muscle fatigue exercises performed each week are the same, but 3 recovery methods (PB, AB and VB) are used respectively during these three weeks. The specific process of the experiment is as follows:

1. Movement familiarization phase. Repeated centripetal and centrifugal contractions of the elbow joint in flexion at an angular velocity of 45°/s for 10 times.
2. Pre-fatigue measurement phase (see Figure 1). Maximum Voluntary Contraction (MVC) and Surface Electromyography (sEMG) were measured sequentially to avoid the influence of mechanical properties on muscle performance testing.
3. Muscle fatigue phase (see Figure 1). The isometric exercise was performed using an elastic rope as a device, and the non-dominant elbow joint was flexed at an angular velocity of 45°/s with repeated centripetal and centrifugal maximal contraction movements, ranging from 30 to 120° (0° with the elbow fully extended) until the last three consecutive muscle performance decreases to 50% MVC, which means muscle fatigue (Wojtys, Wylie and Huston, 1996), and isometric exercise was stopped.
4. In the post-fatigue measurement phase, sEMG was measured immediately.
5. Recovery stage. PB method: Sit with arms relaxed for 1minute; AB method: Stretch, shake, and press the tired muscles for 1minute to relax;

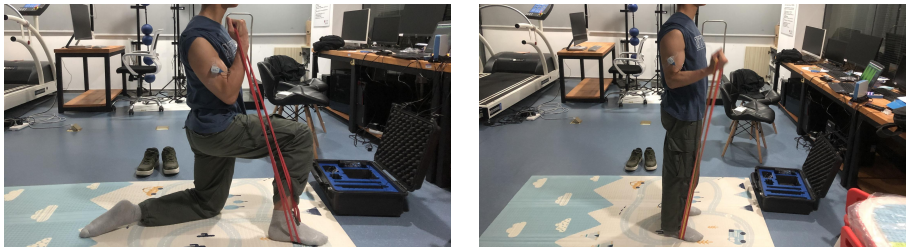

Figure 1: Pre-fatigue measurement phase (left) and Muscle fatigue phase (right).

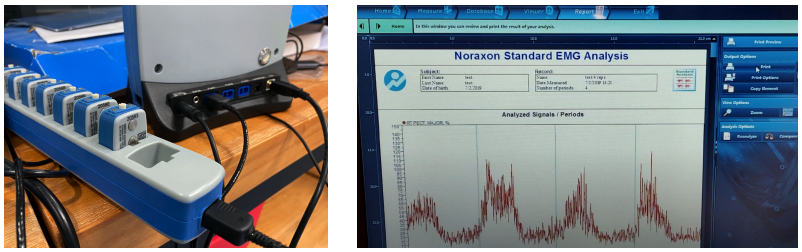

Figure 2: Noraxon Ultium EMG system (left) and Noraxon MR3 software (right).

VB method: Vibrate fatigued muscles by vibration with a fascial gun for 1 minute.

6. Post-fatigue measurement phase. Measure sEMG during 5 minutes immediately after 1 minute of intervention.
7. Perform another recovery method experiment after 7 days until complete recovery.

Measurements and Analysis

In this study, Noraxon Ultium wireless EMG system (see Figure 2) was used to acquire the signals of muscle activities. Noraxon MR3 (see Figure 2) was used to record and analyze the EMG data.

RESULTS

After the experiment, One-Way Repeated Measures ANOVA was used to compare the difference of muscle performance index (MVC, RMS, MF) between groups (PB, AB, VB) at different time points (pre-fatigue, post-fatigue, and post-recovery). JASA method (Luttmann et al. 1996) was also used to analyze the muscle recovery effect, the regression coefficients of RMS and MF were calculated. The results of the analysis are as follows:

1. The median frequency (MF) of the muscles after the VB, AB, PB method show a significant increase, and the RMS show a significant reduction. The mean value of MF after AB method intervention was higher than the mean value of MF after VB method intervention.
2. The mean value of RMS after AB method intervention was lower ($p<0.05$) than the mean value of RMS after VB method intervention

Table 1. The mean value of RMS in 5 minutes after different methods.

Subject No.	PB Method (μV)	AB Method (μV)	VB Method (μV)
1	3.93	1.33	2.05
2	2.95	1.16	2.87
3	2.56	1.05	2.82
4	5.01	1.53	1.57
5	3.46	0.77	1.28
6	2.62	0.94	1.42
7	3.45	1.66	2.00
8	3.75	1.67	2.25
9	7.13	1.52	2.27
10	3.24	0.57	1.62

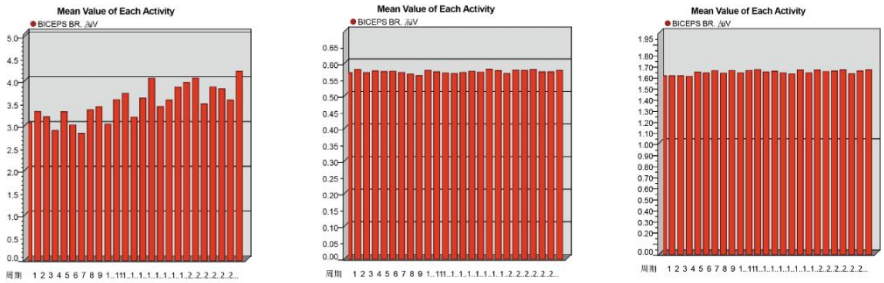

Figure 3: The mean value of RMS in 5 minutes after different methods of Subject No.10.

(see Table 1). Figure 3 excerpts the diagrams which show the mean value of RMS in 5 minutes after different methods of subject No.10.

CONCLUSIONS AND FUTURE WORK

In this paper, we have shown that PB method, AB method and VB method are all effective for muscle fatigue recovery under the conditions of this experiment according to JASA analysis. Besides, 1-minute AB is more effective for muscle fatigue recovery than 1-minute VB, which means when taking 1-minute rest between exercise sets, the effect of AB is better than VB. This is comparable to previous result (Fuller et al. 2015) which suggests that vibration is no more effective than the standard prescription of stretching and massage for promoting recovery of muscle strength. In comparison to previous study, our experiment has two principal advantages. First, we used sEMG and JASA methods as analyzing method instead of analyzing the concentrations of serum biomarkers to avoid invasiveness to the subjects' bodies. Second, the muscle fatigue induction method and the rest intervention method we used are closer to the real fitness habits of Chinese people. By conducting this experiment, we hope to provide references and suggestions for improving exercise performance and reducing injuries after muscle fatigue.

The present study conducted relatively simple experiments in a short period of time to produce the results. In our future work, subsequent experiments could expand the sample quantity, be more rigorous in the control of the stimuli and add subjective ratings.

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