ATLANTIS PRESS
Advances in Engineering Research, volume 125
International Conference on Material Science, Energy and Environmental Engineering (MSEEE 2017)

Comparative experimental study of the effect of different recovery methods on the recovery of sEMG after muscle fatigue

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Keywords: MVC; sEMG; musle power; vibration recovery; cryotherapy.

Abstract. This paper's purpose is to investigate the effect of passive recovery (PR), active recovery (AR), vibration recovery (VR) and cryotherapy recovery (CR) on muscle sEMG after muscle fatigue. 20 healthy male college students were enrolled in the study. sEMG of MVC(Maximum Voluntary Contraction) and MP(Muscle Power) of the biceps brachii of the non-handedness were measured. The differences and recovery effects of sEMG at different detection time points were tested by one-way repeated measures ANOVA. Results shows that sEMG of MVC and MP, VR and PR have obvious effect for recovery after fatigue and VR has more obvious recovery effect compared with AR.

1. Introduction

Passive recovery method (static rest) is generally adopted for fatigue recovery in the past. The method is simple with the minimum restriction, but compared with other active recovery, its recovery effect does not show advantage. Vibration training rising recently belongs to passive recovery method that can generate effect similar with active recovery without active muscle contraction, such as muscular temperature improvement [1], regional blood flow increase, and strength performance improvement, and these characteristics are quite helpful to fatigue recovery. In addition, cryotherapy recovery can also be adopted to lower muscular temperature and promote vasoconstriction, thus lowering blood flow volume, inflammation, tumidness and ache conditions of injured muscle. But present research conclusions on recovery effect of cryotherapy to muscle strength after fatigue are not uniform, and for example, there are researches holding that cryotherapy can recover muscle strength[2], but there are also researches pointing out that muscle strength recovery is relatively slow or it does not have any effect[3], so further confirmation is required.

2. Research object and method

2.1 Object of study

20 male undergraduates having healthy body are subjects (they are free from cardiovascular disease, high blood pressure and relevant viscera disease, and they can receive the maximum exercise test), with average age (20.4±2.3 yrs.), average height (173.5±3.4 cm) and average weight (68.7±3.9 kg).

2.2 Experimental design.

Experimental design of repetitive measurement is adopted, and every subject accepts four different fatigue recovery ways in anti-balance sequence method: PR, AR, VR, CR. Interval of experimental procedure in every step shall be over 7 days to avoid that delayed onset muscle soreness disturbs experimental result.

1) In phase of familiarization with actions, elbow joint shall bend to contract 10 times centripetally and eccentrically repeatedly in 45°/s of angular speed;

2) In phase of measurement before fatigue, BBM Surface Electromyography shall be measured in sequence to avoid that mechanical property is affected by muscle manifestation test.

3) In phase of muscle fatigue, isokinetic exercise system of Biodex System Pro-4 is adopted, and maximum contraction exercise shall be conducted centripetally and eccentrically repeatedly in 45°/s of angular speed on bent of non-habitual elbow joint, and activity scope is 30~120° (it is 0° when elbow completely stretches straightly), and muscles can be judged in fatigue until finally there are continual three times where muscle force manifestation reduces to 50% MVC, and then exercise of constant speed can be stopped.

4) In phase of measurement after fatigue, data of muscle sEMG shall be immediately measured.

5) In phase of intervening of recovery way, one of its recovery ways can be conducted in random way: PR group shall rest for 10 minutes in still sitting gesture; concentric contraction exercise shall be conducted for AR group in constant speed on isokinetic exercise system of Biodex System Pro-4. It shall start in strength of 25% MVC, and the speed shall decrease by 5% MVC every two minutes, and there shall be 10 minutes totally. For VR group, vibration training platform Power Plate Pro5 AIR™ shall be used to partially vibrate BBM, and vibration frequency shall be 30 Hz, amplitude being 2 mm for 10 minutes. Ice compression shall be conducted on fatigue parts with LP ice pack (LP894; M: 22.9 cm; 65% ice block filling) non-pressure device for 10 minutes for CR group.

6) In phase of measurement after recovery, Surface Electromyography of BBM shall be measured immediately.

7) Then experiment of another recovery way shall be conducted until totally recovery with interval over 7 days.

2.3 Test data and collection.

1) Surface myoelectricity. Activation intensity of BBM shall be measured via BIOPAC systems MP150 on elbow joint during MVC and MP. Before measuring sEMG, hair on most bulging skin surface of BBM muscle belly shall be removed and resistance can be reduced via scrub with alcohol pad. It shall be marked after cleaning to reduce error of re-measurement, and then conducting resin shall be painted on surface electromyography, and it shall be pasted in fixation along longitudinal orientation of muscles. sEMG shall be transferred to recorder (BIOPAC systems MP150) upon amplification and recorded in 1000Hz of sampling frequency. Band-pass filtering shall be conducted upon amplification of collected signal via physiological amplifier by Acqknowledge 4.3, and low cut-off frequency is set at 10 Hz, and high cut-off frequency is set at 500 Hz. Then it shall be rectified and righted, and it shall be calculated based on mean square root myoelectric voltage. Mean value of muscle contraction of 2 seconds in 3 seconds shall be cut out for sEMG of MVC. Mean value of 250 ms after electro-myographical signal appears is adopted for sEMG of MP. Standardized processing shall be conducted on EMGrms values of MVC before fatigue for all measured EMGrms values, so as to get relative strength (%).

2) Recovery effect. Values of sEMG at different measurement time points (before fatigue, after fatigue and after recovery) shall be calculated, and then [(after recovery/before fatigue) ×100%-(after fatigue/before fatigue) ×100%] shall be deemed as recovery effect of sEMG.

2.4 Statistical analysis.

Statistical handling shall be conducted via SPSS 19.0, and the result shall be represented with mean value ± standard deviation ($\bar{X} \pm SD$). Difference of sEMG in all groups (PR, AR, VR, CR) at different time points (before fatigue, after fatigue, after recovery) shall be compared respectively via repeated measures of a single factor. Difference among groups of recovery effect can also be compared, and posterior comparison can be conducted via way of Bonferroni if standard reaching is significant. Statistical significance level is $P<0.05$, and non-significance level is $P<0.01$.

3. Change of sEMG after intervening of different recovery ways

3.1 Difference of different time points.

There are only groups of PR and VR reaching significant difference ($P<0.05$) for sEMG in all groups at different time points (after fatigue and after recovery). After comparison, sEMG of PR group and VR group is significantly more than that after fatigue ($P<0.05$) (Table 1).

Table1. sEMG of MVC at different time points

sEMG (%)	before fatigue	after fatigue	after recovery
PR	40.13±7.76	77.39±28.97	93.24±31.26^c
AR	39.46±7.57	76.13±15.92	82.01±22.14
VR	39.04±7.23	69.96±16.48	102.46±28.13^c
CR	38.61±9.05	80.56±15.60	92.87±24.56

Note:a represents significant difference before fatigue and after fatigue; b represents significant difference before fatigue and after recovery; c represents significant difference after fatigue and recovery. P<0.05.

There are only PR and VR reaching significant difference (P <0.05) for sEMG of all groups at different time points (after fatigue and after recovery). MP in groups of PR and VR after recovery is significantly superior to that after fatigue (P <0.05) (Table 2).

Table2. sEMG of MP at different time points

sEMG (%)	before fatigue	after fatigue	after recovery
PR	157.83±24.59	87.86±26.10	109.34±20.51^c
AR	151.83±24.00	91.75±20.30	95.99±27.56
VR	155.02±21.94	84.70±19.47	102.04±22.01^c
CR	153.74±23.81	90.24±12.28	90.72±19.01

Note:a represents significant difference before fatigue and after fatigue; b represents significant difference before fatigue and after recovery; c represents significant difference after fatigue and recovery. P<0.05.

3.2 Difference of recovery effect.

sEMG recovery effects of MVC among all groups reach significant difference (P <0.05), and VR is significantly superior to AR after posterior comparison (Fig. 1). In aspect of sEMG of MP, recovery effects of PR, AR, VR and CR all no not reach significant difference (Fig. 2) (P>0.05).

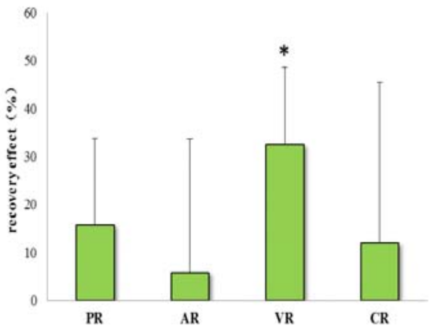

Fig.1 sEMG recovery effect of MVC

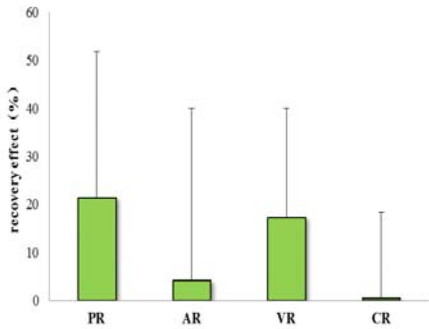

Fig.2 sEMG recovery effect of MP

Note: # represents significantly better than group PR; * represents was higher than that of AR group (p<0.05); & represents was better than that of group CR. P<0.05

4. Summary

Myoelectricity amplitude signal will be suppressed with increase of fatigue degree [4] and the study evaluates muscle activation degree by adopting EMGrms and there will be descending trend for sEMG of MVC and MP, which represents that excitement rate of exercise unit will decrease gradually when muscle fatigue rate increases gradually. After introducing different recovery methods, for sEMG of MVC and MP, VR and PR have obvious effect for recovery after fatigue and VR has more obvious recovery effect compared with AR. VR can improve exercise performance and can increase muscle activation degree mainly because that vibration can give rise to change of muscle length and promote excitement of afferent nerve of muscle spindle Ia, which will be transformed by α exercise nerve fibre through spinal cord and trigger myotatic reflex and improve muscle activation quickly and vibration stimulation can inspire impulsion frequency ability of threshold value II type exercise unit and can control quick constrictor and slow constrictor to reach excitement threshold value simultaneously[5,6]; therefore it is very important to strength performance.

CR group of the study has favorable effect on recovery of strength performance after fatigue, while sEMG aspect of MVC does not have obvious effect possibly because local CR will change temperature and nerve conduction rate will reduce after temperature change and nerve muscle reaction will be influenced directly; however, relevant studies point out that CR has different influence on different muscle fiber tension; before temperature decreases to 20°, quick constrictor tension presents increase trend and slow constrictor tension presents decrease trend; after temperature decreases to 20°, quick constrictor tension and slow constrictor tension present decrease trend; it is researched [7] that it has obvious recovery function for 20 min CR, while there is no obvious change in reaction time after fatigue of quadriceps femoris muscle; therefore, it is verified that 10 min CR adopted in the study has promotion effect for strength performance in short time, while it has no obvious change for sEMG.

Acknowledgments

This work was supported in part by the Project of the Fundamental Research Funds for the Central Universities under Grant LGZD201709, in part by the Project of China Postdoctoral Science Foundation under Grant 2017M611849, in part by Jiangsu Qing LAN Project under Grant 2017, and in part by Nanjing Forest police College Teaching Reform Project under Grant ZD17001 & YB17001.

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