The Research Journal of the Costume Culture pISSN: 1226-0401 eISSN: 1266-0401
Vol. 21, No. 4 pp.606~611, August 2013 http://dx.doi.org/10.7741/rjcc.2013.21.4.606

Tight sportswear and physiological function
- Effect on muscle strength and EMG activity -

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Abstract

It has been reported that tight sportswear could have complicated influence on physiological function of human body. The purpose of this present study was to investigate the effect of wearing gradient compression tights (GCT) on muscle strength and EMG activity during repeated isokinetic muscle contractions. Four healthy male undergraduate students performed maximal voluntary isokinetic concentric muscle contractions on biomechanical test and training systems with GCT and loose pants as control (Cont) respectively. During each test, the peak torque of extensor and flexor contractions and the surface electromyography (sEMG) of the rectus femoris and medial gastrocnemius was recorded simultaneously, the peak torque was recorded as an indicator of muscle strength, and the average amplitude and mean power frequency of sEMG were calculated as indicators of EMG activity. The results showed that: the peak torque decreased gradually during continuous muscle contractions both when the Cont and GCT were worn, average sEMG and mean power frequency declined along with the repetitions of muscle contractions for both wearing conditions, and the change tendency was consistence with that of peak torque. There was no obvious difference between the peak torque recorded wearing the Cont or wearing GCT, but when GCT were worn, average sEMG was lower and mean power frequency was higher than the Cont condition. In 24 samples obtained from four subjects, 80% of results showed the same trend. So we could make a conclusion that wearing GCT had no obvious effect on the improvement of muscle strength, but it would affect the EMG activity positivly.

Keywords: gradient compression tights, muscle strength, sEMG, isokinetic concentric contraction

I. Introduction

High-performance sportswear plays an important role in athletic training and daily exercise, and tight-fit sportswear (e.g. tights, tight tops, compression socks and so on) as a typical kind of high-performance sportswear has gained great popularity among athletes and sports enthusiasts. Some researchers have carried out certain investigations to find out the effect of tight-fit sportswear on exercise performance. Berry and McMurray found that wearing elastic garments could facilitate venous return during the recovery from a treadmill VO2 max test (Berry & McMurray,

A project funded by the Priority Academic Program Development of Jiangsu higher education institutions (PAPD).
The authors would like to greatly appreciate all the volunteered subjects that participated in this study.
Received 25 June 2013, revised 18 August 2013, accepted 19 August 2013.

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1987). Ali, Caine & Snow (2007) found that wearing graduated compression stockings during a 10-km road running test reduced the delayed-onset muscle soreness after exercise (Ali et al., 2007); Chatard et al. (2004) reported that wearing compression garments helped to improve the maximal aerobic performance through reducing blood lactate accumulation during repeated 5-min maximal cycling efforts separated by an 80- min recovery. Kraemer, Bush & Wickham (2001) reported that wearing compression sleeves could promote the strength recovery of a single arm following a heavy eccentric exercise through accelerating creatine kinase clearance. In Bernhardt and Anderson's research, it was shown that athletes achieved significant jump height increases when compression garments were worn during the maximal-effort vertical jump performance (Bernhardt & Anderson, 2005). As supposed, wearing suitable tight-fit sportswear could improve exercise performance by means of reducing soft tissue vibration, accelerating blood circulation, and helping with fatigue recovery during and after exercise.

Knee-based muscle flexion and extension movements are involved in many forms of exercise, such as ball games, jumping, running, bicycle exercise and so on, but only a few researchers used knee-based muscle flexion and extension movements to investigate the effects of graduated compression garments on muscle strength and muscle activities. Kraemer, Bush and Mcbride (1998) reported that no significant differences were found in peak torque when compression tights and loose pants were respectively worn to complete an isokinetic extension task; and Duffield, Cannon and King (2010) found that there was no significant difference in maximal voluntary concentric torque reduction after repetitive sprints performed with and without elastic compression garments either. Generally, in above researches, only the torque generating capacity of muscles during flexion and extension movements were investigated, muscle activity such as muscle discharging during a fatiguing task was not studied on at all. Therefore, the purpose of this study was focused on investigating the effect of gradient compression tights (GCT) on peak torque generation of flexors and extensors and EMG activity of the rectus femoris and medial gastrocnemius during a continuous fatiguing knee-fixed isokinetic concentric muscle contraction performance.

II. Method

1. Subjects

Four healthy male undergraduate students with no history of orthopedic and neuromuscular disorders volunteered to participate in this study. Their mean age, height and weight were 20±1 years, 176±3.5 cm and 70±4.9 kg. The subjects were reported to the laboratory to get acquainted with the experimental equipments and be familiar with the strength testing procedures before the experiment.

In the 24 h prior to and following the test, subjects avoided exercise and consumption of alcohol, while avoiding food, drink, and caffeine 3h prior to testing. Each subject completed six tests. Therefore, the total number of samples was 24 (4 subjects×6 times).

2. Materials

Commercially available tights with degressive pressure distribution from the ankle to the thigh (Graduated Compression Tights, GCT) were used to exert certain pressure on the lower limbs. Common loose pants were used as the experimental control (Cont).

3. sEMG recording

sEMG was recorded with a special myoelectric apparatus (Biovision Inc., Germany) at a sampling frequency of 1,000 Hz. Two couples of recording electrodes were placed on the surface of rectus femoris belly and medial gastrocnemius belly along the alignment of muscle fibers, while the reference electrode was placed on the surface of right side of patella. Before electrodes were fixed on the surface, all the placement locations had been shaved, abraded with sandpaper and cleaned with ethanol, in order to avoid impedance mismatch and movement artifact.

4. Experimental procedure

On each experiment, the subject firstly warmed up on the treadmill for 5 minutes at the speed of 11 km/h (wearing the Cont). After a short rest, he was placed electrodes, then, he was asked to wear GCT or Cont and performed continuous maximal voluntary contractions of the right leg on biomechanical test and training systems (CON-TREX, Zurich Switzerland) at the range of motion for Knee-based muscle extension and flexion between 10° and 85° (0° being full extension) at an angular velocity of 60°/s. They were instructed to exert maximal effort throughout each contraction, there were intervals of 20s among contractions, the test was repeated until the torque declined to half of maximal torque. After an hour rest, they were asked to repeat the exercise wearing another pant. The order of the wearing Cont or GCT was random. For each subject, the experiment repeated on 6 days while among the six tests, there were three times wearing the Cont first. The peak torque and sEMG data were simultaneously and continuously recorded during the test.

5. Data analysis

Average sEMG and mean power frequency values of the rectus femoris and medial gastrocnemius muscles were calculated with wavelet analysis program based on Matlab software. Average sEMG and MPF values were computed over a 1s period around the maximal torque.

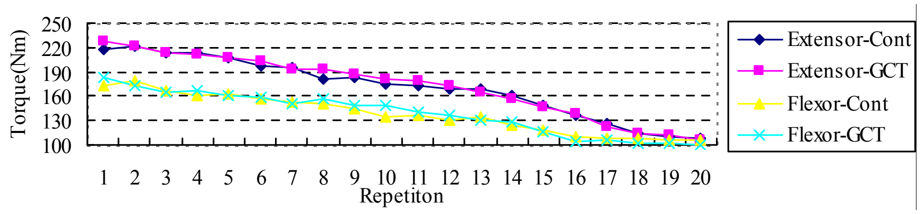
III. Result and Discussion

1. Peak torque

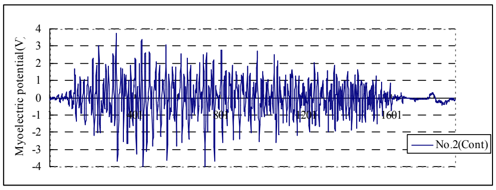
<Fig. 1> showed the peak torque changes of extensor and flexor muscles of S1 during continuous contraction wearing the Cont and GCT respectively. It was clear that the peak torque declined gradually during continuous contractions for both wearing conditions, indicating muscle fatigue. No obvious difference in the peak torque change was observed between two wearing conditions.

2. Electromyographic amplitude

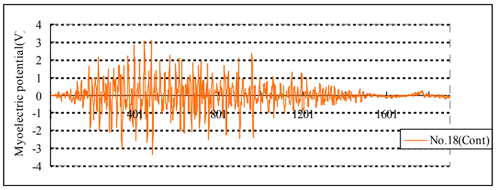
<Fig. 3> showed the sEMG of No. 2 and No. 18 contractions of the rectus femoris of S1 wearing the Cont and GCT respectively. The electromyographic amplitude of No. 18 was smaller than that of No. 2 for the two wearing conditions, the medial gastrocnemius showed the same trend. <Fig. 3> showed the average sEMG of the rectus femoris and medial gastrocnemius muscles for 20 contractions, and the results under the Cont and GCT conditions were compared. Average sEMG decreased during continuous contractions for both wearing conditions, all subjects showed the same trend. The similar finding was reported by Komi and Tesch (1979). But some studies also reported that sEMG amplitude increased during continuous movement (Beck et al., 2004). Many factors effected sEMG amplitude, such as movement of the muscle fiber,



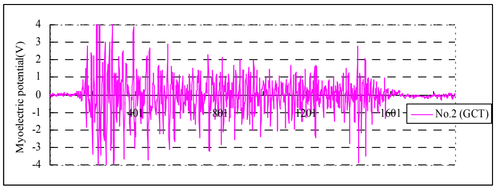
〈Fig. 1〉 Peak torque of continuous contraction (S1)



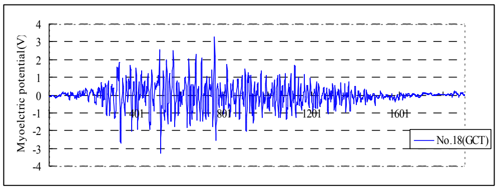
(a) sEMG of No.2 contraction (Cont)



(b) sEMG of No.18 contraction (Cont)



(c) sEMG of No.2 contraction (GCT)



(d) sEMG of No.18 contraction (GCT)

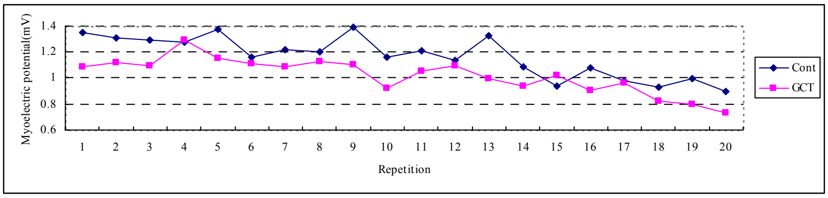
〈Fig. 2〉 sEMG of continuous contraction (S1)

fiber type characteristics, change in motor unit recruitment (Beck et al., 2006). But it was mainly due to muscle fatigue.

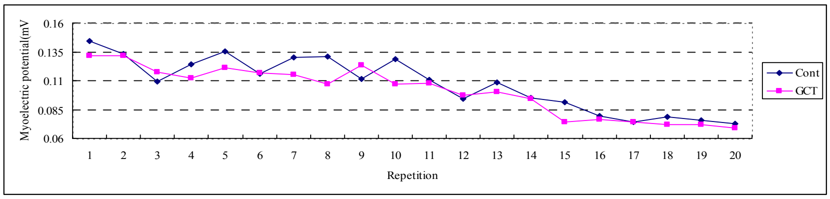
For both No. 2 and No. 18 contraction, the electromyographic amplitude wearing GCT were lower than that wearing the Cont in <Fig. 2>. In <Fig. 3> (a), it was clear that the average sEMG of the rectus femoris under GCT condition was larger than that under the Cont, and the similar trend could be found for the medial gastrocnemius in <Fig. 3> (b). 80% (19 in 24 samples) of samples showed the same trend.

3. Mean power frequency

<Fig. 4> showed that the mean power frequency of the rectus femoris and medial gastrocnemius muscles decreased during continuous contractions for both wearing conditions, all the samples showed the same trend except two samples in which no decrease and increase were observed. It was commonly due to a slowing velocity of the muscle fiber conduction. The

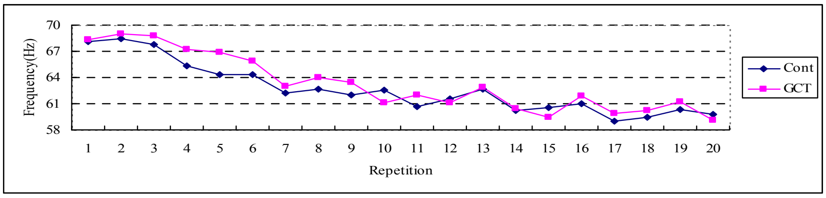


(a) Rectus femoris

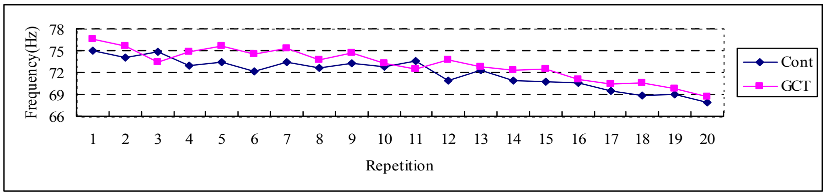


(b) Medial gastrocnemius

〈Fig. 3〉 Average sEMG during continuous contraction (S1)



(a) Rectus femoris



(b) Medial gastrocnemius

<Fig. 4> Mean power frequency of sEMG during continuous contraction (S1)

fiber conduction velocity may be influenced by a lower intramuscular pH which was shown to impair muscle contractile property and shorten velocity (Rassier & Herzog, 2002). And Kranz, Cassel and Inbar (1985) suggested that a decrease in conduction velocity would allow the recording sEMG electrode to monitor the action potentials for a longer time period, thereby, resulting in concomitant decreasing in mean power frequency.

From <Fig. 4> it can be found that mean power frequency wearing GCT is little higher than wearing the Cont. This result was consistence with average sEMG. 80% of the samples showed the same trend.

IV. Conclusion

In this study, through investigating the peak torque changes, electromyographic amplitude, average sEMG and mean power frequency, the effect of wearing GCT on muscle strength and EMG activity were studied, the main finding were as follow: the peak torque decreased gradually during continuous contraction under the Cont and GCT conditions, average sEMG and mean power frequency also declined during continuous contraction for both wearing conditions, and the change tendency was consistence with that of peak torque; There were no obvious differences in torque whether wearing the Cont or wearing GCT, but wearing GCT average sEMG was lower and mean power frequency was higher than that of the Cont. Within 24 samples obtained from four subjects, 80% of results showed the same trend. The rectus femoris and medial gastrocnemius muscles showed the same trend. Therefore, it can be concluded that wearing GCT had no obvious effect on the improvement of muscle strength, but it would have positive effect on EMG activity.

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