

Tremor Associated with Muscle Fatigue Is Temporary and Beneficial: A Case Report

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ABSTRACT

Enhanced physiological tremor (EPT) associated with fatiguing static muscle contractions is generally thought to limit continuous muscle work. However, the EPT dies away, allowing the continuous muscle contraction to be maintained at low-level workload. Here, we report a case study of a 22-year-old male volunteer who performed static plantar flexion at 30% maximal voluntary contraction (MVC) for 66 min with repeated EPT events. Comparative analysis of 1 min pre- and post-EPT phases revealed lower electromyographic (EMG) activity, heart rate, and blood pressure levels during the post-EPT phases, while the popliteal artery blood-flow volume and vascular conductance were raised. EPT may therefore be a mechanism for removing factors that inhibit continuous muscle contraction. This unique case report provides new insight into the functional significance of EPT during prolonged static muscle contractions.

1. INTRODUCTION

Enhanced physiological tremor (EPT) associated with fatiguing static muscle contractions [1-4] limits continuous muscle work. However, EPT also dies away, allowing continuous muscle contraction to be maintained at a low-level workload [5] with reduced electromyographic (EMG) activities after EPT events. Reduced EMG activity after EPT events may lead to an increased blood supply resulting from a decline in acting-muscle tissue pressure [6-8], which would promote metabolite excretion [9, 10]. The motor system may therefore use EPT to facilitate the continuation of voluntary muscle activity. Interactions between neuromuscular function and the blood supply to the acting muscle are also important for the continuation of voluntary movement [11]. However, there is little data on the local circulation and neuromuscular activity before and after EPT events during prolonged muscle contractions. We examined the function of EPT by measuring both neuromuscular activity and local circulation during prolonged static muscle contractions.

2. METHODS

We obtained data from a healthy 22-year-old male volunteer. After giving his informed consent, he performed static plantar flexion at 30% maximal voluntary contraction (MVC) with the foot set on a device freely moving in the direction of plantar-dorsi flexion for 66 min (Figure 1). The protocol was approved by the ethics committee of National Institute of Fitness and Sports. We recorded his ankle joint angle and the surface electromyography (EMG) in his triceps surae (lateral gastrocnemius [LG], medial gastrocnemius [MG], and soleus [Sol]) and tibialis anterior (TA) muscles using a bipolar Ag/AgCl electrode, which wrote to the hard drive of a personal computer via an A/D converter (PowerLab, ADInstruments, Japan) [12]. We also measured his two-dimensional popliteal arterial diameter (AD) and mean blood velocity (MBV) throughout the experiment using an ultrasound Doppler (SSH-140A, Toshiba, Japan) with a linear array transducer (7.5 MHz) [13]. We simultaneously conducted electrocardiography, measured his heart rate (HR) and blood pressure (BP), and continuously monitored his pulse rate (PR) and mean arterial BP with a finger-cuff photoplethysmography device (Finapres, Ohmeda, USA) on his middle finger. We calculated his popliteal artery blood flow (Qpa) as the product of MBV, PR, and arterial cross-sectional area as follows:

$$Q_{pa} = MBV \cdot \pi \cdot (AD/2)^2 \cdot PR, \quad (1)$$

where MBV is mean popliteal artery flow velocity, π is 3.14, AD is arterial diameter, and PR is pulse rate.

3. RESULTS

We found that EPT events initially occurred at 8.7 min, lasted for approximately 14 s, and diminished, after which the static muscle contractions resumed. The tremor rate ranged between 7 and 10 cycles per second (Figure 2). The three individual muscles in the triceps surae showed a clear EMG grouping with an active/inactive time ratio of 1.2 during the EPT events (Figure 2). EMG activity in the TA was unchanged before, during, and after the EPT events. The subject sometimes developed muscle

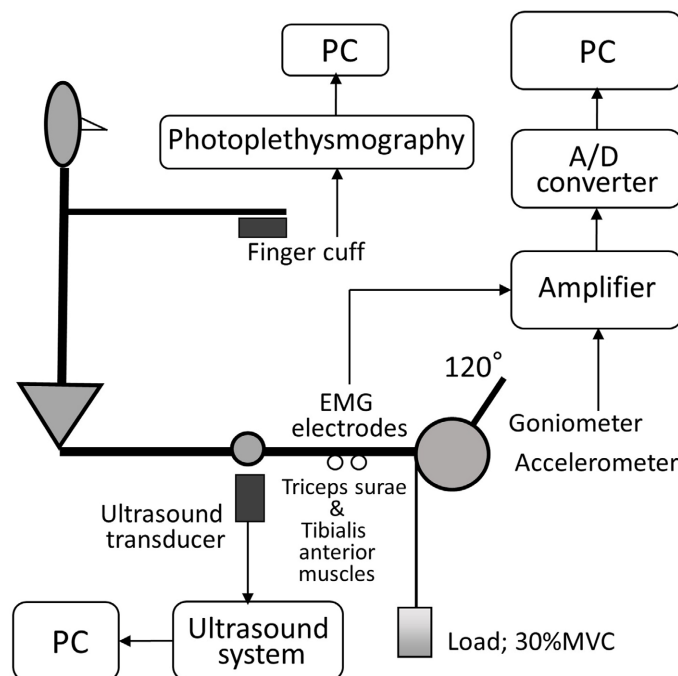


Figure 1. Experimental setup. We recorded the ankle joint angle and surface electromyography in the triceps surae and tibialis anterior muscles. Two-dimensional popliteal arterial diameter, blood velocity, blood pressure and pulse rate were also measured simultaneously.

pain before an EPT event began. The intervals between EPT events were about three times longer in the first half of the endurance test than the second. Comparative analysis of 1 min pre- and post-EPT phases revealed reduced surface EMG activity (Figure 2) and reduced HR and BP (Figure 3) in the post-EPT phase. In contrast, blood-flow volume and vascular conductance increased in the post-EPT phase (Figure 4).

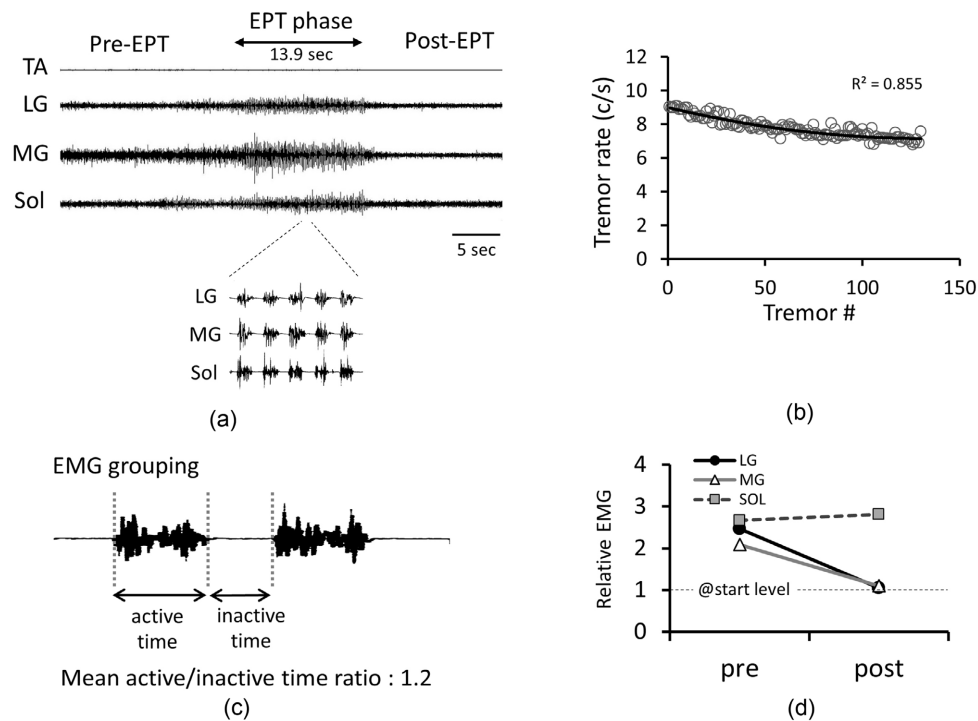


Figure 2. Surface electromyography (EMG) recordings from the lateral gastrocnemius (LG), medial gastrocnemius (MG), and soleus (Sol) before, during, and after enhanced physiological tremor (EPT) events that occurred during static plantar flexion at 30% maximal voluntary contraction (MVC) (a). Rhythmic tremulous activity with EMG grouping can clearly be seen ((b), (c)). Comparative analysis of 1 min pre- and post-EPT phases revealed reduced EMG activity in LG and MG (d).

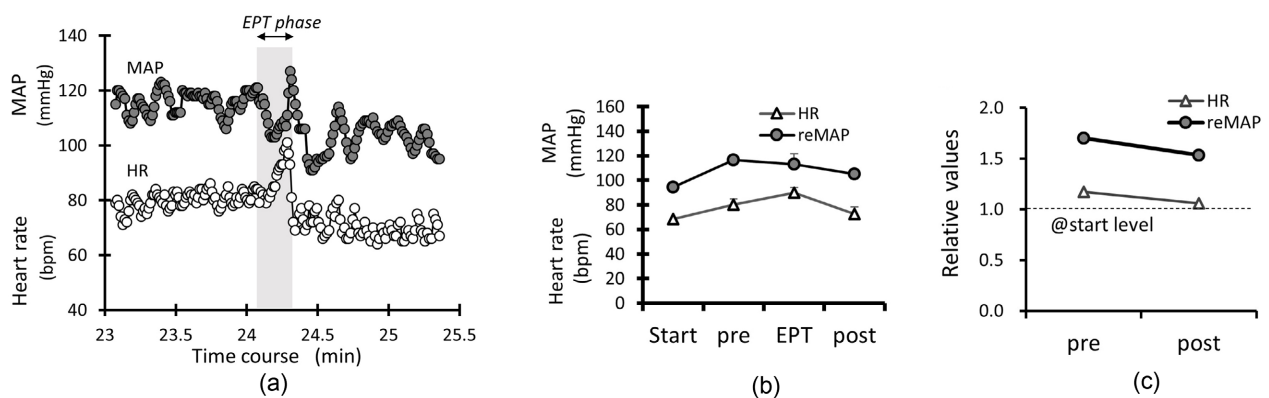


Figure 3. Time course of mean arterial pressure (MAP) and heart rate (HR) before, during, and after enhanced physiological tremor (EPT) events ((a), (b)). Relative changes in MAP and HR pre- and post-EPT normalized by the values at the beginning of the static muscle contractions (c).

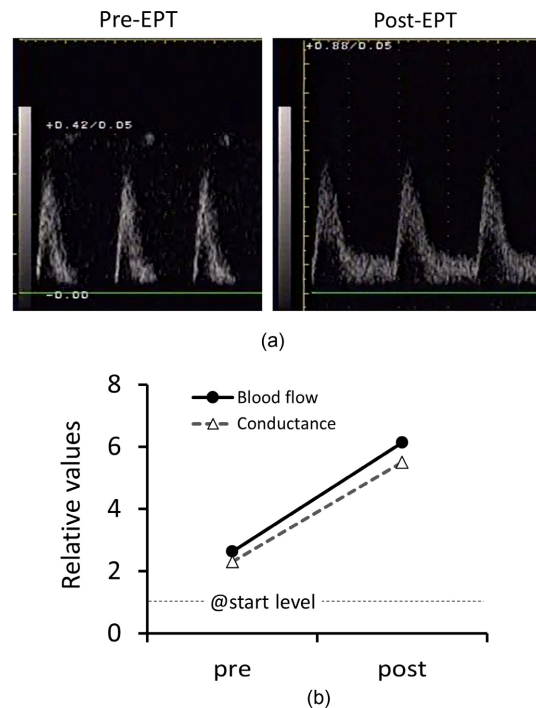


Figure 4. Typical examples of Doppler velocity spectra before and after enhanced physiological tremor (EPT) events during static muscle contractions (a). Relative blood-flow and conductance values pre- and post-EPT normalized by the values at the beginning of static muscle contractions (b). The post-EPT values were raised compared to the pre-EPT values.

4. CONCLUSION

Overall the results showed that the EPT events during prolonged static muscle contractions dead away and then muscle contractions continued. The subject had a tremor rate ranging between 7 - 10 c/s. EMG activity, HR and BP were reduced, while arterial blood flow and vascular conductance increased in the post-EPT phase. EPT events associated with fatiguing static muscle contractions may therefore act as a function of the muscle pump and lead to temporary normalization of homeostasis in muscle tissue. This novel insight into EPT function may provide useful information for the fields of sports medicine and rehabilitation.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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