ACOUSTIC MYOGRAPHY: A NON-INVASIVE METHOD FOR MEASURING SHIVERING

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Recording shivering in thermoregulatory studies is important for: 1) Analyzing the short-term variations in muscle thermogenesis, and 2) Teasing apart the shivering and non-shivering components of adaptive thermogenesis. In contrast to brown fat thermogenesis, shivering is amenable to second-by-second monitoring of the thermogenic process by recording the contractile activity of the muscle fibers. This is typically done by electromyography. However, electromyography in animals is invasive as surface electromyograms (EMG) usually cannot be obtained. To develop a non-invasive method for measuring shivering, this study examines the use of piezoelectric sensors to record the contractile activity from muscle surface as an acoustic myogram (AMG), i.e., recording the low-frequency sound waves that emanate from contracting motor units. Acoustic myography has already proved useful in clinical neuroscience and sports medicine (1). For the present study, AMGs from a small piezoelectric rod together with intramuscular EMGs from 3-pin needle electrode were recorded from pectoralis muscles of domestic pigeons and Japanese quail at 3 ambient temperatures (Ta) below thermoneutrality. The piezoelectric sensor used is originally designed for measuring eye movements in humans during sleep. The EMG-electrode was inserted into the belly of the muscle and the piezoelectric sensor was placed within 1 cm of the electrode. Both sensors were then fixed on muscle surface by adhesive tape. After amplification and filtering, r.m.s. values of EMG and AMG were obtained and recorded with data acquisition software. Both the short-term (second-to-second at the same Ta) and long-term (Ta-induced) variations were highly correlated in both species. Cold acclimation did not change the correlation. In the second phase, a low-cost modification was developed. Miniature piezoelectric loudspeakers (ca. 1.5 €/unit) glued to muscle surface with medical cyanoacrylate were used to pick-up the AMG. A similar strong correlation was found. In contrast to measuring gross tremors by accelerometry, AMG (like EMG) measures the amount of contractile activity more reliably, as the amplitude of tremors depends heavily on motor unit synchronization within the muscle and between antagonistic muscles. Earlier studies show that tremors can even decrease despite of increased motor unit activity (2). Acoustic myography is thus a feasible approach for measuring shivering.

1. Harrison AP, Clinical Physiology and Functional Imaging 2018 38, 312-325.
2. Hohtola E & Stevens ED, Journal of Experimental Biology 1986 125, 119-135.