1660 ELECTRODE PLACEMENT IS NOT RESPONSIBLE FOR THE DIVERGENT INCREASES IN EMG AND FORCE WITH STRENGTH TRAINING

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Some strength training studies with the first dorsal interosseus muscle (FDI) have failed to show parallel increases in EMG and force (Keen et al, JAP 77: 2648, 1994; Laidlaw et al, JAP 87: 1786, 1999). To determine whether the placement of the surface electrodes in relation to the innervation zone was responsible for the non-parallel increases in EMG and force, four young adults (29 ± 2 yrs, 2 males and 2 females) underwent strength training of the FDI for 4 weeks. Training was performed three times per week and each participant performed 6 sets of 10 repetitions of 80% 1-RM load. Strength was assessed with an isometric maximum voluntary contraction (MVC) and a one repetition maximum (1 RM). The EMG of the left FDI was measured using two pairs of bipolar surface electrodes (4 mm in diameter, silver-silver chloride). The first pair was secured over the innervation zone of the FDI, whereas the second pair of electrodes was placed at the distal end of the muscle. MVC force increased by 26.1% (19.2 ± 8.4 N) and 1-RM load by 55.3% (941.6 ± 420.9 g). The peak EMG amplitude recorded during the MVC from the distal pair of electrodes (891.0 ± 175.6 µV) was significantly greater than the EMG recorded from the pair of electrodes placed over the innervation zone (676.7 ± 154.7 µV). Similarly, the integrated EMG recorded during the 1 RM was greater for the distal pair of electrodes (1727.8 ± 448.2 µV·s vs. 1371.1 ± 349.0 µV·s). The EMG from both pairs of electrodes varied similarly over the four weeks of training. This change in EMG, however, did not parallel the increase in MVC force or 1-RM load. These results suggest that electrode placement was not responsible for the non-parallel increases in EMG with force during strength training.
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1661 THE EFFECTS OF DIFFERENT ENDURANCE TRAINING INTENSITIES ON SYSTEMATIC AND PERIPHERAL CITRATE SYNTHASE ACTIVITY

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To investigate the effects of different endurance training intensities on systematic and peripheral muscle aerobic adaptation, thirty-two male Wistar rats (7-wk old) were randomly assigned into three exercise groups (EXE1, EXE2, and EXE3) and a control group (CON). The rats of the three exercise groups were trained on the treadmill 5 days/wk, 1 h/day for 8 wks. Training intensities began at 12m/min and increased progressively to 30m/min with a 5o grade for EXE1; 22m/min with a 0o grade for EXE2; and 12m/min with a 0o grade for EXE3. After sacrifice, citrate synthase (CS) activity was measured in the heart muscle, fast-twitch extensor digitorum longus (EDL) muscle and slow-twitch soleus (SOL) muscle. The CS activity of the heart muscle did not differ significantly among groups. However, soleus CS activity in the EXE1 group was 19% higher than the EXE3 group, and 24% higher than the CON group ($p < .05$). No significant difference was found in EDL CS activity between groups. In conclusion, endurance training did not induce aerobic adaptation of the systematic muscle (heart muscle) and fast-twitch muscle (EDL). However, different training intensities would raise CS activity of slow-twitch soleus muscle to different levels. Supported in part by NSC 89-2413-H-003-022, TAIWAN

1662 A MODEL FOR CONTROLLING AND QUANTIFYING VOLITIONAL MUSCLE PERFORMANCE OF RAT PLANTAR FLEXORS IN VIVO

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An in vivo animal model was developed to study the effects of volitional eccentric, concentric, and isometric muscle actions and varying work-rest cycles on muscle performance, behavior, and histological and biochemical response. Using a custom-designed apparatus that was attached to a standard operant chamber, rats were operantly conditioned with food rewards to perform a voluntary lifting task to generate controlled movement of the plantar flexors. An opening in the front panel of the operant chamber allowed the rat to enter a Plexiglas tube that was mounted vertically to restrict the movement of the rat. A load cell was embedded in a platform at the bottom of the tube to measure the dynamic force exerted by the plantar flexors. Inside the tube, a neck ring was supported by a yoke that moved along two vertical shafts via linear bearings. A displacement transducer (LVDT) was attached to the weight pans to measure the range of motion of the lift, and allowed determinations of velocity and acceleration of the lifting motion. The apparatus allowed the rat to enter the tube through the opening, insert its neck into the ring, and lift the ring assembly. In this way, eccentric and concentric muscle contractions were produced. In some cases, weights were placed on pans attached to the ring assembly to vary the load. In other cases, movement of the yoke was locked at different heights such that multi-positional isometric performance could be studied. The entire process was computer automated, and vertical displacement, time during each lift, and dynamic forces exerted during each lift were sampled at 100 Hz via a computer-controlled data acquisition system. This model allows skeletal muscle performance to be studied longitudinally and in a controlled biomechanical environment. This model also is well suited to study the effect of chronic volitional muscle actions and work-rest cycles on behavioral and physiological outcomes.

1663 A RAT MODEL FOR THE QUANTIFICATION OF UPPER-EXTREMITY VOLITIONAL MUSCLE PERFORMANCE

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An in vivo animal model for the study of musculoskeletal disorders associated with repetitive strain is described. Using intact rats, operant conditioning with food rewards was used to train voluntary isometric exertions of the forelimb. The procedures allowed the acquisition of highly repetitive and uniform responding that was maintained in daily sessions conducted up to several weeks duration. Rats were operantly conditioned with food rewards to respond on a force lever which recorded response force in real time. The force criterion was set to 0.25 N, and 0.50 N in some cases, and food rewards were delivered according to variable-interval schedules of reinforcement. This schedule produced rapid and steady rates of responding. Sessions lasted 1-2 hours each were conducted five days per week for up to 8 weeks and functional measures such as force, rate, and duration of responses were recorded throughout. Highly uniform response topographies were obtained with all rats. Representative response patterns obtained under various work conditions will be shown along with force-time response functions of individual animals to illustrate the response topographies that resulted under various biomechanical requirements and reinforcement contingencies. There are several advantages of this model compared to invasive in vitro or in situ preparations of isolated muscle fibers or other less invasive in vivo models such as rodent dynamometry and treadmill running. Biomechanical parameters such as the force, duration, and rate of responding can be precisely controlled by manipulations of the reinforcement contingencies, while leaving muscle-tendon complex and normal neuromuscular-control processes intact. When combined with biochemical and histological analyses, this model can provide a comprehensive and externally valid model for studying muscle pathomechanics and varying work-rest cycles that will broaden the scope of musculoskeletal research.

1664 INFLUENCE OF INCOMPLETE SPINAL CORD INJURY ON LOWER EXTREMITY MUSCLE MASS

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Weight bearing activities are essential to the maintenance of muscle mass. In accord with this concept, complete spinal cord injury (SCI) causes rapid atrophy that can be extensive. The atrophic response is muscle specific, reflecting relative differences in unloading among muscles. Individuals with incomplete SCI are often community ambulators, but frequently present with reduced strength in one or both lower limbs. This pilot study examined incomplete SCI patients to determine if apparent differences in loading were reflected in muscle size of the involved and non-involved lower limb. Four subjects (37 ± 8 yr, 79 ± 7 kg, mean ± SE) at least one year post an incomplete SCI participated. Magnetic resonance (MR) images of the thigh and leg were taken to asses muscle cross sectional area. Subjects verbally indicated which of their lower limbs was involved. This was confirmed by determining the 1 repetition maximum for each knee extensor muscle group. In all subjects, the involved limb had a lower 1 RM than its non-involved counterpart. On average, the quadriceps femoris ($p<0.001$), adductor ($p<0.025$), and hamstring ($p<0.001$) muscle groups of the non-involved thigh were 5 to 8% larger than those of the involved extremity. The m. gastrocnemius, soleus and tibialis anterior of the leg did not show differences between limbs ($p>0.05$). These preliminary results suggest relatively less loading of the involved thigh in chronic, incomplete SCI. This may reflect the general impression that most of the ambulation these patients perform is over level ground, thereby emphasizing use of the calf. In contrast, when they do ascend stairs, for example, they apparently favor their non-involved thigh. Supported by the Foundation for Physical Therapy (CSB)

1665 ENZYMES OF ENERGY SUPPLY AND DEMAND AND GLYCOGEN USE

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Percutaneous biopsies were taken from the right m. vastus lateralis of three recreationally active males (age 31.4 ± 2.3 yr, mean +/- SE) and analyzed for succinate dehydrogenase activity (SDH, mmol fumerate/l/min), actomyosin adenosine triphosphatase activity (qATPase, mmol/l/min), and glycogen content (OD) of typed fibers using standard histochemistry/microdensitiometry. SDH and qATPase were used as estimates of energy supply and energy demand, respectively. Samples were taken before and after 30 min of non-fatiguing electromyostimulation (EMS) to test the hypothesis that the ratio of SDH:qATPase would be a better predictor of glycogen use than SDH or qATPase alone. Fibers were considered to have shown glycogen loss if the post-EMS OD was > one SD below the pre EMS, "resting" average for a given fiber type. Subsequently, the decline in OD for each of these fibers from "rest" was used to infer the extent of glycogen loss. 20 Hz, 450 µs biphasic pulses, 1 s on:3 s off, were used for EMS. The current was set to evoke 30% of maximal voluntary contraction, suggesting complete activation of m. vastus lateralis because it occupies about 1/3 of m. quadriceps femoris. SDH:qATPase explained more of the variability in glycogen loss (decrease in OD = 0.991 x ratio - 0.770 , $r2$ = 0.532, p 0.0001) than SDH (decrease in OD = -0.000 x SDH activity + 0.197, $r2$= 0.257, $p = 0.020$) or qATPase activity (decrease in OD = 0.002 x qATPase activity + 0.023, $r2$ = 0.312, $p = 0.003$). It has recently been shown that SDH:qATPase is a better predictor of fatiguability for individual muscle fibers than SDH alone. Thus, it seemed logical that SDH: qATPase would also be a better predictor of glycogen utilization during intermittent muscle stimulation. Based on our results, it is concluded that the ratio of energy supply to energy demand, represented by SDH:qATPase, is a better predictor of glycogen utilization during non-fatiguing contractions than either of its components independently. Supported by NIH HD-33738-01

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