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Motor unit behavior during submaximal contractions following six weeks of either endurance or strength training

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Vila-Chã C, Falla D, Farina D. Motor unit behavior during submaximal contractions following six weeks of either endurance or strength training. *J Appl Physiol* 109: 1455–1466, 2010. First published September 9, 2010; doi:10.1152/japplphysiol.01213.2009.—The study investigated changes in motor output and motor unit behavior following 6 wk of either strength or endurance training programs commonly used in conditioning and rehabilitation. Twenty-seven sedentary healthy men (age, 26.1 ± 3.9 yr; mean ± SD) were randomly assigned to strength training (ST; $n = 9$), endurance training (ET; $n = 10$), or a control group (CT; $n = 8$). Maximum voluntary contraction (MVC), time to task failure (isometric contraction at 30% MVC), and rate of force development (RFD) of the quadriceps were measured before (*week 0*), during (*week 3*), and after a training program of 6 wk. In each experimental session, surface and intramuscular EMG signals were recorded from the vastus medialis obliquus and vastus lateralis muscles during isometric knee extension at 10 and 30% MVC. After 6 wk of training, MVC and RFD increased in the ST group (17.5 ± 7.5 and 33.3 ± 15.9%, respectively; $P < 0.05$), whereas time to task failure was prolonged in the ET group (29.7 ± 13.4%; $P < 0.05$). The surface EMG amplitude at 30% MVC force increased with training in both groups, but the training-induced changes in motor unit discharge rates differed between groups. After endurance training, the motor unit discharge rate at 30% MVC decreased from 11.3 ± 1.3 to 10.1 ± 1.1 pulses per second (pps; $P < 0.05$) in the vasti muscles, whereas after strength training it increased from 11.4 ± 1.2 to 12.7 ± 1.3 pps ($P < 0.05$). Finally, motor unit conduction velocity during the contractions at 30% MVC increased for both the ST and ET groups, but only after 6 wk of training ($P < 0.05$). In conclusion, these strength and endurance training programs elicit opposite adjustments in motor unit discharge rates but similar changes in muscle fiber conduction velocity.

motor unit; surface electromyography; motor training

MOTOR PERFORMANCE IS ENHANCED by repeated exposure to exercise training. Depending on the desired goal, exercise paradigms may include strength, sprint, endurance, or skill training. The muscular and neural adaptations induced by each type of exercise approach are highly specific and may vary for different training paradigms. Typically, endurance training involves generalized muscle activation performed over many repetitions (34, 62). Exercises such as running or cycling are classic examples of endurance training and are known to improve the ability to sustain rhythmic movements for longer periods, mainly due to increased maximal oxygen uptake and increased ability of skeletal muscles to generate energy via oxidative metabolism (28). At the other extreme, strength training typically involves exercises for specific muscle groups that are performed over a short duration, e.g., performing few repetitions at high force levels (34, 58, 62).

Distinct anatomical and physiological adaptations in response to conventional strength and endurance training have been documented (for review, see Refs. 21–23, 28). Because these two types of exercise programs represent extremes of physical activity (58), they may also elicit different neural adaptations. Accordingly, the increases in maximal strength and rate of force development achieved with strength training appear to be impaired when endurance and strength training are applied concurrently (27, 49). This effect has been mainly attributed to an opposite influence of the two training regimes on the neural control of muscles (16, 27). For example, Hakkinen et al. (27) showed that muscle activity at the onset of a rapid isometric explosive contraction was impaired by concurrent endurance and strength training even though similar morphological adaptations occurred with respect to strength training only. In addition to muscular adaptations, the effects of strength and endurance training on motor performance reflect supraspinal and spinal adjustments (6, 15), which ultimately influence the neural drive to the muscles, i.e., the behavior of motor units. However, as recently discussed (15), in vivo data on motor unit properties following training are scarce. Only a few studies have investigated motor unit behavior following strength training (31, 51, 56, 61), and the results remain controversial. For example, increased motor unit discharge rates have been observed after explosive (61) and dynamic strength training (31); however, no changes were observed after isometric training (54, 56). Furthermore, the effects of training on the discharge rates assessed during maximal and submaximal contractions show mixed results (31, 54, 56).

Currently there are no available data on changes in motor unit discharge behavior following endurance training. Although there are speculations on changes in motor unit recruitment and discharge rates with endurance training, these conclusions are largely based on reflex studies (37, 42, 52) and animal experiments (8, 9). For example, Pérot et al. (52) reported an increase of the H-reflex after 8 wk of endurance training, indicating a potential increase in motor neuron pool excitability. Accordingly, for the same relative force level, endurance training was shown to increase the proportion of recruited low-threshold motor units (52). However, it is not possible to draw firm conclusions on changes in motor unit behavior based on the H-reflex response (24, 63).

The specificity of adjustments in motor unit behavior with different types of training is poorly understood, mainly due to

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