TRAINING INDUCED QUALITATIVE ADAFTATIONS ON THE ELECTROMYOGRAPHIC (EMG) PATTERN OF THE LEG EXTENSOR MUSCLES

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INTRODUCTION

The combination of eccentric and concentric actions forms a natural type of muscle function called a stretch-shortening cycle or SSC (Komi, 1984). Such SSC exercises are more efficient than pure concentric exercises (Aura and Komi, 1986). The prestretching increases the stiffness of the muscle-tendon complex and thus favors conditions that allow performance potentiation in the subsequent concentric phase. The fact that both the facilitatory and inhibitory sensory inputs from the muscle take part in the stiffness regulation implies that there is a great potential for adaptation. For training purposes, it is relevant that training could cause not only quantitative changes of the neuronal input to the muscle but also a qualitative shifting in the electromyographic (EMG) patterns (Schmidtbleicher et al. 1988).

The present study was designed to investigate the changes in force-time characteristics and in neuronal activation patterns before and after a training period using SSC exercises.

METHODOLOGY

Thirteen healthy males were involved in a 4 week training program. The subjects exercised 3 to 4 times per week. They performed reactive DJ from their best drop height. In each training unit they exercised 3 - 4 sets with 10-20 repetitions each and a rest interval of 5 minutes inbetween sets. The testing procedures took place before and after the training period. The subjects performed squat jumps (SJ), conter-movement jumps (CMJ) and reactive drop jump (DJ) exercises from the heights of 25, 40, 55 and 70 cm. The vertical ground reaction forces, the angular displacement of the knee and ankle joints as well as the surface electromyograms (EMG) of the triceps surae muscles (GAS and SOL), vastus medialis (VM) and biceps femuris (BF) were recorded. Each jump was performed six times. After normalization, force, angle displacement and EMG signals, were averaged for each jumping condition. The EMGs were full-wave rectified and integrated (iEMG) over different functional phases (Dietz et al., 1979): Preactivation phase (PRE) (100ms before ground contact); Reflex Induced Activation phase (i.e. the activation phase from 40 ms to 120 ms after impact); Late EMG Response phase (LER) (activity from 120 ms until the end of contact).The significance of the differences between means were tested with t-test for paired samples.

RESULTS

Table 1 summarizes the results of the height of rise of center of gravity (HRCG) and the contact times (CT) of all test conditions.

The results of the height of rise of center of gravity (HRCG) showed non significant differences in SJ and CMJ conditions. In DJ conditions the HRCG increased from 38.8±4.0 cm to 41.4k4.2 cm ($p<0.001$) in DJ25, from 39.2±4.6 cm to 41.8k4.8 cm ($p<0.001$) in DJ40, from 38.6±4.8 cm to 40.9k5.7 cm ($p<0.01$) in DJ55 and from 39.6±4.4 cm to 41.1±5.3 cm ($p<0.01$) in DJ70. These increses were followed by a reduction in Total Contact Time (TCT) from 241.2k40.3 ms to 192.1 k18.1 ms ($p<0.001$) in DJ25, from 237.2±32.4 ms to 197.1±18.1 ms ($p<0.001$) in DJ40, from

257.7 ms±40.2 ms to 209.5±19 ms (p<0.005) in DJ55 and from 290.3259.9 ms to 224.8±14.5 ms (p<0.001) in DJ70. These reductions in TTC were due to decreases, both in the eccentric and concentric contact times.

Table 1. Mean and standard deviation values of height of rise of center of gravity (HRCG) and the contact times (CT), before and after the training period.

	HRCG (cm)	HRCG (cm)	CT (ms)	CT (ms)
	Before	After	Before	After
SJ	37.4 ± 3.5	37.0 ± 3.5	293.0 ± 39.7	287.7 ± 35.6
CMJ	37.5 ± 3.8	37.8 ± 4.0	376.0 ± 64.5	372.1 ± 55.9
DJ25	38.8 ± 4.0	41.4 ± 4.2****	241.2 ± 40.3	192.1 ± 18.1****
DJ40	39.2 ± 4.6	41.8 ± 4.8****	237.2 ± 32.4	197.1 ± 18.1****
DJ55	38.6 ± 4.8	40.9 ± 5.7**	257.7 ± 40.2	209.5 ± 19.0***
DJ70	39.6 ± 4.4	41.2 ± 5.3**	290.3 ± 59.9	224.8 ± 14.5****

* p<0.05; ** p<0.01; *** p<0.005; **** p<0.001

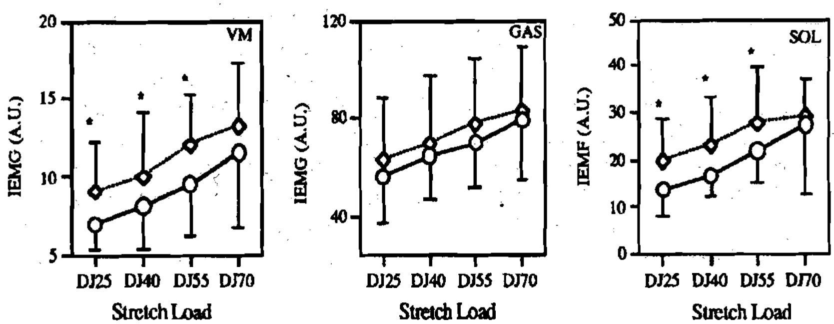

Fig. 1. Mean and standard deviation values of the integrated electromyographic activity (IEMG). of the Vastus Medialis (VM), Gastroctemius (GAS) and Soleus (SOL) muscles, in the Pre-Activation (PRE), in the diferent stretch load test conditions, before (0) and after (x) the training period. * p<0.05.

The iEMG of the PRE phase (Fig. 1) showed a moderate increase in all studied muscles, however these changes were only statistically significant for VM and SOL in DJ25 (p<0.01), DJ40 (p<0.05) and DJ55 (p<0.01). As expected. the iEMG of the PRE phase increased lineraly with the stretch load.

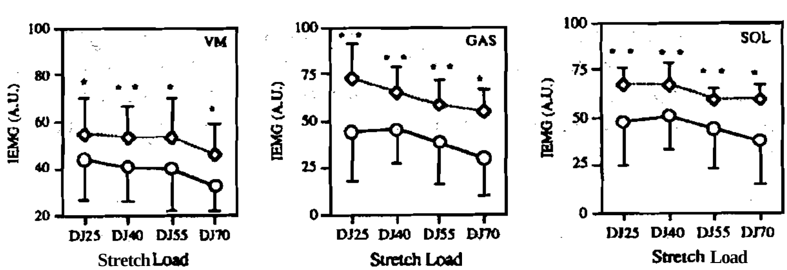

Fig. 2. Mean and standard deviation values of the integrated electromyographic activity (IEMG), of the Vastus Medialis (VM). Gastroctemius (GAS) and Soleus (SOL) muscles, in the Reflex Induced Activation (RIA) phase, in the diferent stretch load test conditions, before(O) and after (x) the training period.*p<0.05; **p<0.01; ***p<0.005.

Higher increases ($p<0.01$) could be observed in the RIA phase (Fig. 2). These changes were statistically significant for all studied muscles and DJ conditions. The iEMG of the LER phase decreased ($p<0.01$) in all tested conditions and for all studied muscles.

DISCUSSION

The improvements in physical performance (HRCG) were more evident in SSC actions than in purely concentric muscle actions - SJ (Schmidtbleicher et a1.1988). On the other hand, the changes in SSC exercises were only statistically significant in short SSC muscle actions (DJ) and not in long SSC type of muscle actions (CMJ). Previous reports (Gollhofer, 1987) pointed out the relatively independence of muscle function in a SSC, compared with pure concentric, eccentric or isometric muscle actions. The present results, seems to suggest that among SSC type of exercises, there is also some independence between short (DJ) and long (CMJ) SSC.

As a result of training the iEMG of the PRE phase increased, which means in functional terms, that the ncuromuscular system adapted to pre-activate at a higher level, resulting in an increase of muscle stiffness during the early contact phase. This increase of muscle stiffness is crucial to resist to the muscle elongation and avoid cross-bridges disattachment.

Additionally, the results of the electrical activity of the muscles, showed a qualitative shifting in the EMG - patterns toward an accented RIA-phase activation, after the training program with SSC exercises. This means that the neural input to the muscles not only changed in quantitative terms, but also qualitatively. As previously suggested (Gollhofer et al. 1992), in DJ exercises during the earlier ground contact the lengthening of the muscles might be taken up predominantly in the tendon acting as the main elastic buffer. After the firsts 40 ms, the tension and lengthening of the muscle-tendon-complex may become critical with respect to the preactivation obtained before ground contact. At this moment a powerfull neuronal input is required to balance the system. The duration of this RIA phase is in good agreement with the time periods for the short-and medium-latency components of the stretch reflex (Dietz, 1987). This reflex potentiation will probably have a role in muscle stiffness regulation and consequently prepares the muscle-tendon-complex for better storage and utilization of elastic energy, which enhances the neuromuscular performance.

CONCLUSIONS

An important requesite for an effective SSC is a hight degree of stiffness of the muscle-tendon-complex during the contact phase. The present power training caused specific changes in the functioning of the neuromuscular system. The observable higher performances were due to a qualitative shifting on the EMG pattern toward an accented activation starting 40ms after the ground contact and lasting aproximatly 80ms. This period corresponds with the time periods for the short-and medium-latency components of the stretch reflex (Dietz, 1987). It suggests that training with short SSC exercises can modify the reflex control in the early moments of the contact phase. This can cause the muscles to tolerate better hight-impact loads and to have good recoil characteristics.

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