INTRODUCTION

Despite full voluntary effort, activation of the quadriceps group of muscles appears inhibited during slow concentric and eccentric contractions. Maximum voluntary eccentric strength (MVC) can be more than 50% lower than the values observed in vitro [4]. Pain & Forrester [2] suggested that this apparent reduction could be due to a neural, tension-limiting, mechanism that becomes active during maximal contractions of large skeletal muscles.

Amiridis et al. [1] showed that the difference in force outputs between electrically stimulated and MVC contractions was significantly lower for elite athletes than for sedentary individuals, suggesting that strength training may reduce the inhibitive action of the neural mechanism. The aim of this study was to investigate whether performing a short high velocity eccentric strength training protocol on an isovelocity dynamometer can lead to a decrease in the inhibition during fast eccentric and slow concentric MVC.

METHODS

Six male subjects (age 26.3 ± 2.73 years) took part in the study that consisted of 8 training sessions over a period of 4 weeks. During a pre-training testing session subjects performed five maximal voluntary (MVC) isometric contractions at 15°, 30°, 45°, 60° and 75° and six maximal voluntary isokinetic knee extensions and flexions at 50, 100, 150, 250, 350 and 450°/s. Each MVC trial was followed by an electrically stimulated one. The stimulation of the quadriceps muscles was performed transcutaneously via the femoral nerve. A total of 10 isometric and 12 isokinetic contractions were performed. To assess the effects of training the same testing protocol was repeated post-training.

A nine parameter maximum torque-angular velocity-angle function was fitted to the raw, experimental data to obtain the maximum theoretical tetanic torque parameter, $T_{ecc}$, the maximal voluntary torque parameter, $T_{eccmvC}$, as well as the minimum level for a differential activation function, $a_{min}$, that represents the greatest level of neural inhibition. Additionally to assess activation level the interpolated twitch technique was used. To express voluntary activation (VA) as a percentage of theoretical maximal activation of the quadriceps muscle the following formula was employed:

$$\%VA = \left(1 - \frac{\text{superimposed twitch}}{\text{control twitch evoked at rest}}\right) \times 100$$

where the superimposed twitch is the force increment noted during a maximal contraction at the time of stimulation and the control twitch is that evoked in the relaxed muscle [3].

The analysis focused on the comparison of peak eccentric, $T_{ecc}$, maximal voluntary torque, $T_{eccmvC}$, the minimum level of muscle activation, $a_{min}$, parameters as well as the raw peak torque values between pre- and post-training sessions. Student’s paired t-test or, in exceptional cases where data was non-parametric, the Wilcoxon’s test, were used. A statistical level of significance, $p \leq 0.05$, was used throughout the statistical analysis. Data is reported as mean ± SD

RESULTS AND DISCUSSION

On average subjects achieved higher torque outputs during the post-testing session (Fig. 1), however, statistically significant differences were observed only during eccentric contractions at 350°/s, $p < 0.05$, $t_5 = -2.94$, concentric contractions at 100°/s,
$p < 0.05, \ t_5 = -2.77$ and isometric contractions, $p < 0.05, \ t_5 = -2.74$. Both $T_{ecc}$ and $T_{eccmvc}$ values were significantly, $p < 0.05$, greater post-training (356 ± 30.9 Nm vs. 313 ± 39.4 Nm; mean ± SD) and (279 ± 31.5 Nm vs. 244 ± 36.9 Nm) respectively. Similarly, the low level differential function, $a_{\min}$, was also significantly greater post-training, $p < 0.05$, (0.62 ± 0.04 vs. 0.67 ± 0.05). The percentage values of voluntary activation (%VA) estimated using the twitch interpolation technique were higher, post-training, for all isovelocities tested, though only the values recorded during eccentric contractions at 50°/s (67.1 ± 10.4 vs. 76.1 ± 4.36, $t_5 = -2.58, \ p < 0.05$) were significantly higher post-training.

Figure 1: Plot of average raw torque outputs over angular velocities

Raw torque output increased post-training for all angular velocities tested and during both eccentric and concentric contractions with the biggest increases observed during eccentric and concentric contractions at the highest velocities. Moreover, the voluntary activation levels of the quadriceps muscles showed an increase during the post-training testing session, being on average higher than the respective pre-training values.

The fitted torque values (Fig. 2) provide a means for comparing and evaluating the raw experimental torque data once it has been processed to remove problems with noise, especially one sided errors due to submaximal voluntary efforts. Both, $T_{ecc}$ and $T_{eccmvc}$ values showed a significant increase post-training which suggests that a greater number of muscle fibres of the quadriceps muscles was recruited during the post-training test. Since 8 sessions of isokinetic training are probably not sufficient to elicit muscle fibre hypertrophy, or some other mechanical change, the increased force output can probably be attributed to neural adaptations. The increase in $a_{\min}$ post-training suggests a significant increase in the muscle activation post-training which may be attributed, in part, to the reduced action of the tension limiting mechanism. This is further supported by the increase in the values of %VA post-training.

Figure 2: Typical torque–angle–angular velocity raw data (black circles) and fitted surfaces for the quadriceps of one subject.

CONCLUSION

Performing a short, strength training protocol over a range of high angular velocities led to an increase in muscle activation, and, a possible decrease in the inhibitive action of the tension-limiting mechanism.

REFERENCES
