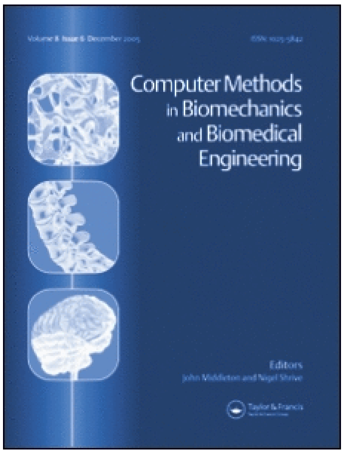

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Influence of sporting expertise on the EMG–torque relationship during isometric contraction in man

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Keywords: EMG–torque relationship; expertise; myotypology; coordination; coactivation

1. Introduction

Muscular contraction is the result of chemical and electrical phenomena whose resultant effect on the environment can be quantified as the net joint torque generated by the muscles around the mobilised joints. The electrical activity associated with this effort can be recorded at the muscular level by electromyography (EMG), thus allowing us to study the relationship between EMG and torque, fundamental in biomechanics for the understanding of the mechanisms underlying the production of a muscular effort.

Although numerous studies have addressed this issue, the nature of the relationship between EMG and torque remains debated and highly controversial, even during isometric contractions. It can be described as linear, quasi-linear, quadratic (Metral and Cassar 1981) or more complicated: linear for low force levels whereas muscle activity increases at a higher rate than force for high force levels (Monod and Flandrois 2003).

Among the factors which influence the nature of the EMG–torque relationship, this study examines the effects of expertise in force production exercices considering that muscle fibre composition and motor unit synchronisation specific to experts (Fukunaga 1976) contributes to enhance the performance of the muscular contraction.

2. Methods

Ten healthy men gave their informed consent to participate in this study: 5 novices and 5 experts in force production exercises.

The angular positions of the lower limb segments were recorded at 200 Hz using a Vicon MX system (Oxford Metrix, Oxford, UK); the ground reaction was sampled at 1000 Hz with an AMTI force platform (AMTI, Newton, MA, USA); surface EMG from the gastrocnemus, biceps femoris, rectus femoris and vastus medialis (VM) muscles was collected at 1000 Hz using a Bagnoli-8 EMG system (DE-2.1, Delsys, Inc., Boston, MA, USA).

The participants were sat down with their trunk vertical, their thighs horizontal, their lower legs flexed at 90°, and their right foot firmly attached to the force platform. After determination of the maximal voluntary isometric contraction force (MVC) at the right knee in flexion then in extension, each participant performed six muscle contraction trials, each composed of a 10 s knee extensors isometric contraction (0–100% MVC) followed by a 10 s knee flexors isometric contraction (0–100% MVC). Each contraction was separated by 10 s rest and each trial was separated by 3 min rest.

After computation of the resultant knee joint torque, quantification of the EMG activity at each force level (0–100% MVC in steps of 5% in flexion and extension) and normalisation of data, the EMG–torque relationship was assessed, and the data were fitted by linear or curvilinear regressions.

An approximation of VM muscle fibre composi-tion was assessed using the non-invasive indirect method from EMG mean frequency analysis (Wretling et al. 1987).

3. Results and Discussion

Figures 1 and 2 show the EMG–torque relationship obtained during flexion/extension isometric contractions in experts and novices, respectively; Table 1 show VM muscle fibre type 1 proportion.

Generally speaking, Figure 1 shows that the EMG–torque relationship remains linear for the experts whatever the flexor or extensor muscle and its role (agonist or

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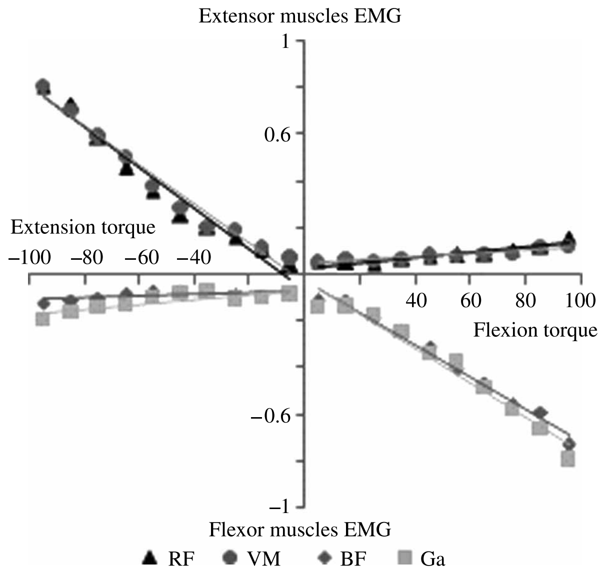

Figure 1. Normalised EMG–torque relationship in experts.

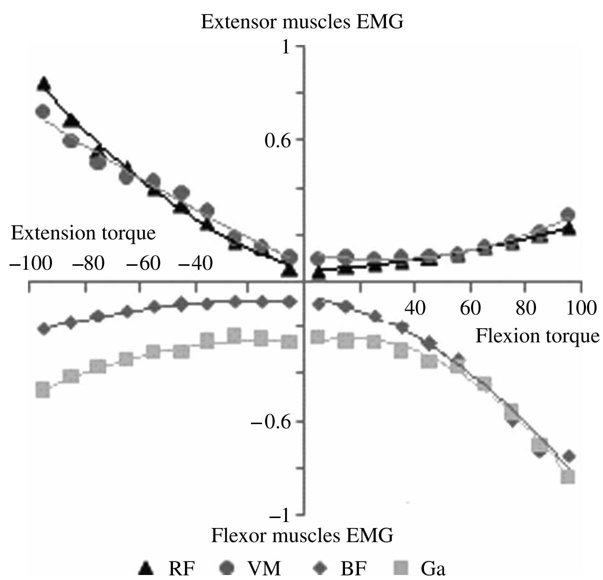

Figure 2. Normalised EMG–torque relationship in novices.

Table 1. VM Fibre type 1 proportion values estimated from EMG frequency content (Wretling et al. 1987) for experts and novices.

VM Fibre type 1 proportion (%)		
Participant n°	Novices	Experts
1	44	39
2	45	41
3	46	33
4	48	46
5	55	33

antagonist) during the contraction. On the contrary, for the novices Figure 2 shows that the EMG–torque relationship is curvilinear (quadratic) whatever the muscle and its role during the contraction, R2 of the linear fit being systematically below the minimum threshold of 0.95.

Even if the muscle fibre composition should be considered as approximate in this study, the comparison of the results obtained in experts and novices shows that the nature of the EMG–torque relationship is not related to the muscle fibre composition.

Although motor unit synchronisation was not quantified in this study, these results suggest that the highest number of muscular fibres recruited in a same time by a motor unit in experts could contribute to *optimise* the performance of the muscular contraction.

Regarding agonist–antagonist coactivation, our results further indicate that the EMG activity of the antagonist muscles is lower for experts than for novices whatever the level of torque during both knee flexion and extension isometric contractions. Considering simultaneously the EMG changes in agonist muscles, results indicate that coactivation for novices is twice as high as for experts.

Thus, for experts, the increase in the reciprocal activity of agonist and antagonist muscles would be dedicated to increase the net joint torque while ensuring the efficient maintenance of the joint stability. For novices, the results suggest that these roles would be performed to the detriment of the energetic expenditure: (i) because increase in EMG activity of the agonist muscles is higher than that necessary to increase the net joint torque and (ii) because of the high increase in EMG activity of antagonist muscles.

4. Conclusions

The present study shows that the EMG–torque relationship cannot be considered as strictly linear, and that expertise in force production exercises affects the nature of this fundamental relationship. Results especially highlight the influence of specific motor unit synchronisation on the *optimisation* of muscle contraction.

These results are expected to find direct applications for biomechanical models devoted to the estimation of muscle forces.

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