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NEUROMECHANICAL TIME DELAY ASSESSMENT OF LOWER LIMB CONTROL DURING LONG, SHORT AND NO COUNTERMOVEMENT

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1 INTRODUCTION

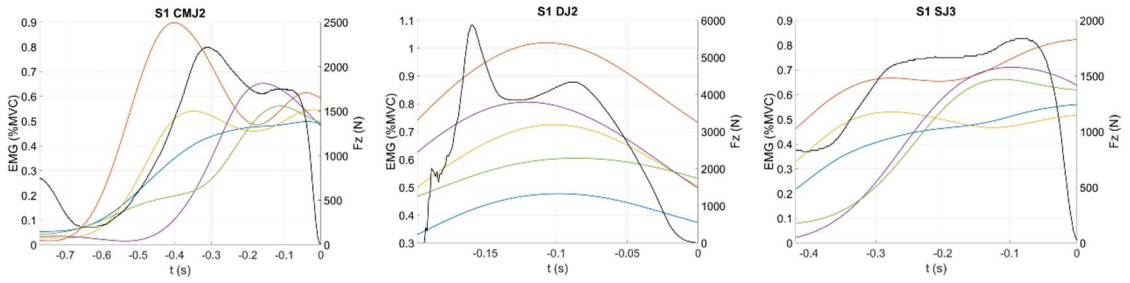
Human gait and posture critically depend on musculoskeletal action. Although isometric, and isolated concentric and eccentric muscle action have received larger research attention [1], natural muscle function frequently involves stretch-shortening cycle (SSC) with stretching immediately preceding muscle contraction for powerful maximal and optimal submaximal action. The relation of muscle activity with force development [2] has thus been dominantly assessed on isometric and isolated concentric and eccentric muscle action, with an open issue on the relation of force development with the muscle activity under more realistic condition such as muscle SSC. For this reason, lower limb muscle SSC has been increasingly assessed on maximal vertical jump (MVJ) with long, short and no countermovement (CM) and SSC [3], with the present study comparison on the relation of the force development with neuromuscular control at each CM condition, due to its application on MVJ performance at different sports as well as on gait and running efficiency.

2 MATERIAL AND METHODS

The maximum cross-correlation (*CCr max*) of surface electromyography (sEMG) from lower limb selected muscles and developed vertical ground reaction force (*GRFz*) during impulse phases was assessed on MVJ with long CM on countermovement (CMJ), short CM on drop jump (DJ) and no CM on squat jump (SJ). A sample of six students of sports and physical education with 21.5 ± 1.4 years, 76.7 ± 9.3 kg mass and 1.79 ± 0.06 m height performed each 3 SJ, 3 CMJ and 3 DJ repetitions. Subjects wore sEMG Skintact F55 aqua-wet gel electrodes placed according to SENIAN convention at lower limb selected muscles vastus lateralis (VL), rectus femoris (RF), vastus medialis (VM), medial gastrocnemius (MG) and lateral gastrocnemius (LG), with sEMG acquired at 2000 Hz and transmitted by a 32 channel BioTel 99 telemetry system. During each trial ground reaction force was acquired at 1000 Hz by a force platform AMTI BP2416-4000CE Model connected to AMTI Mini Amp MAS-6 amplifier. sEMG raw signal was rectified and filtered with second order Butterworth low-pass filter at 5Hz cut-off frequency as proposed by Winter [2] applied at forward and backward directions to avoid phase shift.

3 RESULTS AND DISCUSSION

A total of fifty-four trials from conditioned sEMG signals normalized to maximum voluntary contraction (MVC) were cross-correlated with corresponding *GRFz* for detection of neuromechanical time delay (τ) of maximum *CCr* at long, short and no CM, as presented in Figure 1 during CMJ (*a*), DJ (*b*) and SJ (*c*) impulse phases for one of the assessed performers.



(*a*) (*b*) (*c*)

Figure 1 – Time profiles of lower limb muscles sEMG linear envelopes at the quadriceps (— VL, — RF, — VM) and the gastrocnemius (— MG, — LG) along with vertical ground reaction force (— *GRFz*) during CMJ (*a*), DJ (*b*) and SJ (*c*) impulse phases for one of the assessed performers (S1).

sEMG activities from lower limb selected muscles quadriceps (VL, RF, VM) and gastrocnemius (MG, LG) presented higher mean values of *CCr max* with corresponding *GRFz* during impulse phases on SJ than CMJ, both higher than DJ, with higher dispersion at CMJ as well as at the gastrocnemius on DJ as opposed to SJ. Also, higher mean time lead (τ) was detected on CMJ for VL, with higher time delay (τ<0) for the gastrocnemius, pointing to the lag of MG, LG sEMG in relation to developed *GRFz* on CMJ impulse phase with the anticipation of VL sEMG onset.

Table 1 – Maximum cross-correlation (*CCr max*) and corresponding time-delay (τ) of conditioned sEMG from lower limb selected muscles vastus lateralis (VL), rectus femoris (RF), vastus medialis (VM), medial gastrocnemius (MG) and lateral gastrocnemius (LG) with vertical ground reaction force (*GRFz*) during impulse phase on CMJ, DJ and SJ.

CCr max	**EMG(VL)**	**EMG(RF)**	**EMG(VM)**	**EMG(MG)**	**EMG(LG)**
CMJ	0.935 (0.059)	0.911 (0.058)	0.935 (0.058)	0.903 (0.063)	0.893 (0.053)
DJ	0.878 (0.026)	0.889 (0.025)	0.866 (0.041)	0.850 (0.054)	0.872 (0.060)
SJ	0.959 (0.019)	0.939 (0.037)	0.967 (0.026)	0.983 (0.009)	0.980 (0.011)
τ (s)	**EMG(VL)**	**EMG(RF)**	**EMG(VM)**	**EMG(MG)**	**EMG(LG)**
CMJ	0.060 (0.164)	0.008 (0.030)	-0.018 (0.007)	-0.046 (0.042)	-0.052 (0.041)
DJ	-0.017 (0.020)	-0.007 (0.025)	-0.015 (0.019)	-0.013 (0.017)	0.010 (0.022)
SJ	-0.002 (0.009)	0.001 (0.022)	-0.011 (0.020)	-0.017 (0.010)	-0.026 (0.005)

4 CONCLUSION

Detected pattern on the relation of developed force with muscle activity under realistic condition at different muscle SSC, through maximum cross-correlation and corresponding time delay, provides determinant information for the selection of CM condition towards MVJ performance.

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