

# 電気刺激を用いた新しい筋力トレーニング

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## Novel Strength Training Using Electrical Stimulation

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### ABSTRACT

Muscle fatigue is a major limiting factor in the use of functional electrical stimulation (FES) for strength training. FES induces rapid muscle fatigue because muscle fibres have to be activated at unnaturally high frequencies to generate functional contractions. To overcome this weakness, we have proposed a unique method called Spatially Distributed Sequential Stimulation (SDSS), and tested its advantage in isometric contractions for major leg muscles. The purpose of this project was to test if SDSS was capable of reducing fatigue for isokinetic knee extension. Eleven healthy volunteers participated. Intermittent stimulation (0.3-s on : 0.7-s off; 120-s total) was delivered to the knee-extensors using the conventional method (Single-Electrode-Stimulation; SES) (1 active electrode; 40 Hz) and SDSS (4 active electrodes, each stimulated at 10 Hz; composite 40 Hz stimulation) in separate trials, to generate isometric ( $0^\circ/s$ ) and isokinetic ( $180^\circ/s$ ) torque. Measures of fatigability included fatigue index (FI, average

peak torque of last 10 contractions  $\div$  average peak torque of initial 10 contractions) and torque peak mean (TPM, average peak torque of all 120 contractions  $\div$  average peak torque of initial 10 contractions). FIs were significantly higher for SDSS than SES during isometric (SES =  $0.616 \pm 0.092$ ; SDSS =  $0.761 \pm 0.165$ ;  $p = 0.002$ ) and isokinetic (SES =  $0.645 \pm 0.147$ ; SDSS =  $0.800 \pm 0.175$ ;  $p = 0.002$ ) contractions. TPM values were significantly higher for SDSS than SES during isometric (SES =  $0.781 \pm 0.068$ ; SDSS =  $0.846 \pm 0.108$ ;  $p = 0.022$ ) and isokinetic (SES =  $0.788 \pm 0.103$ ; SDSS =  $0.883 \pm 0.075$ ;  $p = 0.014$ ) contractions. We have reproduced previous findings that SDSS reduces fatigability of isometric contractions compared to similar sized contractions generated by SES. Further, we have extended these findings to isokinetic conditions. The present findings are important for facilitating the utility of FES for use in strength training.

## 要 旨

電気刺激を用いた筋力トレーニング法 (FES 筋力トレーニング法) は, 最先端の筋力トレーニング法として普及始めているが, 早期の筋疲労が問題である. 我々は早期筋疲労を防ぎ, FES 筋力トレーニングをより効率化する新規な電気刺激法である SDSS 法を提案してきた. 本研究では, 等速性膝関節伸展動作において SDSS 法の効果を検証することを目的とした. 若齢被験者 11 名を対象とした. SDSS 法および従来法を用いて 2 分間の反復刺激中の等尺性および等速性膝関節伸展トルクを計測した. その結果, 両運動形態ともに, SDSS 法の方が従来法に比較して疲労低減効果が高いことが示された. 以上より, SDSS 法はこれまで実行可能性検証のために用いられてきた等尺性運動のみならず, より臨床的な等速性運動においても有効であることを示せた. SDSS 法が FES 筋力トレーニングを効率化しうる可能性が示唆された.