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Validation and Use of a Musculoskeletal Gait Model to Study the Role of Functional Electrical Stimulation (Article)

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Abstract

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Objective: Musculoskeletal modeling has been used to predict the effect of functional electrical stimulation (FES) on the mechanics of the musculoskeletal system. However, validation of the resulting muscle activations due to FES is challenging as conventional electromyography (EMG) recording of signals from the stimulated muscle is affected by stimulation artefacts. A validation approach using a combination of musculoskeletal modeling and EMG was proposed, whereby the effect on nonstimulated muscles is assessed using both techniques. The aim is to quantify the effect of FES on biceps femoris long head (BFLH) and validate this directly against EMG of gluteus maximus (GMAX). The hypotheses are that GMAX activation correlates with BFLH activation; and the muscle activation during FES gait can be predicted using musculoskeletal modeling. Methods: Kinematics, kinetics, and EMG of healthy subjects were measured under four walking conditions (normal walking followed by FES walking with three levels of BFLH stimulation). Measured kinematics and kinetics served as inputs to the musculoskeletal model . Results: Strong positive correlations were found between GMAX activation and BFLH activation in early stance peak ($R = 0.78$, $p = 0.002$) and impulse ($R = 0.63$, $p = 0.021$). The modeled peak and impulse of GMAX activation increased with EMG peak ($p < 0.001$) and impulse ($p = 0.021$). Conclusion: Musculoskeletal modeling can be used reliably to quantify the effect of FES in a healthy gait . Significance: The validation approach using EMG and musculoskeletal modeling developed and tested can potentially be applied to the use of FES for other muscles and activities. © 1964-2012 IEEE.

SciVal Topic Prominence

Topic: Tendons | Muscles | tendon stiffness

Prominence percentile: 95.143

Author keywords

Functional electrical stimulation | musculoskeletal modelling

Indexed keywords

Engineering controlled terms: Electrodes | Electromyography | Functional electric stimulation | Iron | Kinematics | Muscle

Engineering uncontrolled terms: Force | Functional electri-cal stimulations | Functional electrical stimulation | Legged locomotion | Musculoskeletal model | Musculoskeletal modelling | Positive correlations | Validation approach

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References (41)

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1 Hodkin, E.F., Lei, Y., Humby, J., Glover, I.S., Choudhury, S., Kumar, H., Perez, M.A., (...), Jackson, A.

Automated FES for upper limb rehabilitation following stroke and spinal cord injury (Open Access)

(2018) *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 26 (5), pp. 1067-1074.
https://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=7333
doi: 10.1109/TNSRE.2018.2816238

View at Publisher

2 Kobetic, R., Triolo, R.J., Marsolais, E.B.

Muscle selection and walking performance of multichannel FES systems for ambulation in paraplegia

(1997) *IEEE Transactions on Rehabilitation Engineering*, 5 (1), pp. 23-29. Cited 124 times.
doi: 10.1109/86.559346

View at Publisher

3 Sharma, N., Mushahwar, V., Stein, R.

Dynamic optimization of FES and orthosis-based walking using simple models

(2014) *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 22 (1), art. no. 15, pp. 114-126. Cited 21 times.
doi: 10.1109/TNSRE.2013.2280520

View at Publisher