The Chinese University of Hong Kong

Department of Biomedical Engineering

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Venue: Room 222, Ho Sin Hang Engineering Building, CUHK

What happens when Electrically Evoked Muscle gets Fatigued: A Mechanomyography and Muscle Oxygenation Perspective

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Abstract

Repetitive electrically-evoked muscle contraction leads to accelerated muscle fatigue. Electrically-evoked fatiguing muscle changes the mechanomyography root mean square percentage (%RMS-MMG) and tissue saturation index (%TSI) in muscle in able bodied (AB) and in individuals with spinal cord injury (SCI). It is important to highlight the relationship in AB individuals first to understand the natural behavior of the muscle mechanically and physiologically as AB has more power in their muscle to perform exercise compared to SCI individuals. AB and SCI performed repetitive electrical-evoked wrist extension to fatigue and results were analysed pre- and post-fatigue, i.e. 50% power output (%PO) drop. Responses of %PO, %TSI and %RMS-MMG were correlated while relationship between %RMS-MMG and %TSI were investigated using linear regression. Seven SCI individuals (N=7) were recruited and %TSI was positively correlated with %PO pre-fatigue. At post-fatigue, %TSI negatively correlated with declining %PO as the ability of the muscle to take up oxygen became limited due to fatigued muscle. The %RMS-MMG behaved the same way during pre- and post-fatigue against declining %PO whereby both showed positive correlation (%RMS-MMG decreased) throughout the session. Regression analysis showed %TSI was proportional pre-fatigue and inversely proportional to %RMS-MMG during post-fatigue. As big gradient was observed from the regression during post-fatigue, it is suggested that changes in %TSI was sensitive enough to the changes in %RMS-MMG. Most correlation and regression for both AB and SCI changed significantly post-fatigue indicating that after fatigue, the condition of muscle had changed mechanically and physiologically. In case where torque cannot be independently quantified, a torque monitoring system using an artificial neural network (ANN) with mechanomyography (MMG) can be deployed. The MMG signals from the quadriceps were used to derive muscle torques during prolonged functional electrical stimulation (FES) assisted isometric knee extension contractions and during standing in spinal cord injured (SCI) individuals. Models revealed significant trends in torque decrease, both suggesting a critical point at 50% torque drop where there were significant changes observed in RMS and ZC trends. Based on these findings, it can be concluded that MMG based RMS and RMS-ZC models performed similarly well in predicting knee extension torque in this population. The developed ANN model could be used to predict muscle torque in real-time thereby providing possibly safer automated FES control of standing in persons with motor-complete SCI.

Biography

Dr Nur Azah Hamzaid is Senior Lecturer at the University of Malaya, Malaysia. She obtained her bachelor in Mechatronics Engineering (Hons) in 2006 and then pursued her PhD in Rehabilitation Engineering at the University of Sydney, Australia. While her background is hard engineering, her interest in applying her Mechatronics Engineering knowledge into the rehabilitation field brought her to the Faculty of Health Science for her PhD, where she undertook clinical and biomechanics courses. Her PhD project was to develop and investigate the effect of a novel isokinetic FES leg stepping trainer for individuals with Spinal Cord Injury which was used by the patients in the Rehabilitation Gym in the University of Sydney Lidcome campus for their FES training sessions. She is now at Biomedical Engineering Department in UM since 2010, pioneering the Biomechatronics, Neuroprosthetics and Functional Electrical Stimulation (FES) research group in Malaysia. Dr Azah, as she is fondly called by her students in UM, teaches Biomechatronics and Prosthetics & Orthotics courses which include FES in Rehabilitation Robotics. In her second year of service in UM she was appointed as the Coordinator of Bachelor in Biomedical Engineering (Prosthetics & Orthotics), the first degree program aiming to produce Prosthetics & Orthotics Engineers in Malaysia. Her heavy involvement in curriculum restructuring, stakeholder analysis, students' clinical placements and patients care as a teacher, researcher and program coordinator got her involved closely with ISPO Education group and the University Malaya Medical Centre, especially the Department of Rehabilitation Medicine – where she made many good and close research and teaching colleagues. Her work on Prosthetics for Rural areas in particular, got her involved with the CoPP group which included partners from the Netherlands, South Africa, and Indonesia, which is in line with the WHO GATE initiative and ISPO. Other than that, she is working on multiple projects for people with disabilities such as Spinal Cord Injury, amputation, stroke and children education with industry and community partners such as Ottobock Austria, EP-SI Singapore, UM Innovations Sdn Bhd and UMCares. She is currently the Head of Research Training Unit in Academic Development Centre (ADEC), UM, and is also currently the President of International FES Society Malaysia Chapter and Board Member of ISPO Malaysia Chapter. She is also the co-founder and current leader of the outreach program "Let's Go To Mummie's Lab". She has published at least 40 ISI-listed journal papers, a number of conference papers, a book chapter and have filed a few patents. Dr Azah has so far graduated 2 PhD and 2 MEngSc students and she is currently supervising 3 PhD students and a few Masters students. She has also won a few Innovation Awards from PECIPTA, Malaysia Technology Expo (MTE), BioMalaysia, i-ENVEX and her work are featured in national mass media including Nona TV3, apart from UM Award for PhD completion in less than 3 years. Her aim is to improve the Rehabilitation Engineering field in Malaysia by uplifting the knowledge and application through quality teaching and curriculum enhancement, better student experience and involvement in and out of class and in research, and bridging the gap between actual society and patient's need and technology provision through sustainable means.

ALL ARE WELCOME***

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