Project Details	
Project Code	MRC22PHSEx Dirks
Title	The development of an electrical stimulation device to optimise muscle health: combining biomechanical engineering and muscle physiology to improve clinical outcomes in fully sedated ICU patients
Research Theme	Population Health Sciences
Summary	Patients in ICU experience extensive muscle wasting, causing insulin resistance and a rise in blood glucose. Regular neuromuscular electrical stimulation (NMES) could prevent these problems, but there is no simple device that can deliver this in the ICU. Using biomechanics and engineering approaches we will develop a 'smart' NMES device that can self-adjust to provide optimal muscle stimulation. We will then test this device on healthy volunteers and ICU patients.
Description	Patients on intensive care units (ICU) suffer from extensive muscle wasting. This leads to the development of insulin resistance (IR), which in turn results in blood glucose levels rising, and affects long-term outcomes such as morbidity and mortality. Since commonly used intensive insulin therapy has a potential negative impact on clinical outcomes, alternative strategies to maintain glycaemic control are required. IR is (partly) caused by bed rest-associated physical inactivity, and re-introducing muscle contraction could attenuate, or even prevent, its development. However, active strategies (e.g. early ambulation) are not feasible in comatose patients. Neuromuscular electrical stimulation (NMES) is an exercise mimetic that evokes muscle contractions by administering small electric currents via self-adhesive electrodes. Although we have shown that NMES can abolish the ~20% ICU-induced muscle wasting (Dirks et al. 2015 Clin Sci), its effect on muscle glucose uptake is unknown. The overall aim of this project is to investigate the impact of NMES on muscle glucose uptake and glycaemic control in fully sedated ICU patients. Existing NMES devices are unsuitable for clinical use as they require regular adaptation (i.e. every few minutes) of the stimulus intensity to ensure full muscle contractions; impractical due to staff time limitations. Therefore, the aim of this studentship is to develop a 'smart' NMES device that can (i) measure the degree of muscle contraction, and (ii) subsequently adapt stimulus intensity when muscle contractions decrease, to ensure full muscle contractions during each entire session. To achieve these aims, the student will have the opportunity to explore the steps below to develop their research questions and design appropriate, novel approaches: 1) Explore potential methods to measure and monitor the degree of muscle contraction, including (but not limited to) electromyography (EMG), motion analysis (captured via marker-based, marker-less and wearable sensors), and Ultrasound, in the Musculoskeletal Biomechanics Research Facility (Holt). 2) During step 1), the student will have regular discussions with Morris; the current R&D lead for the Department of Medical Physics and Clinical Engineering with extensive experience in medical device development. 3) Validate the selected approach to ensure the ability to repeatedly and accurately quantify the degree of muscle contraction in healthy volunteers (Cardiff/Exeter), with the possibility to also perform this in ICU patients (RD&E). 4) Apply the 'smart' NMES method to quantify its effect on glucose uptake of a

	single muscle group in healthy volunteers in the Nutritional Physiology Research Unit at Exeter. The student may use local/whole-body disuse (e.g. limb immobilization/bed rest), and state-of-the-art techniques such as the forearm balance method or hyperinsulinaemic-euglycaemic clamp to measure local/whole-body insulin sensitivity. These techniques were established and are performed routinely by Dirks, in collaboration with Andrews, in preparation for her Fellowship. 5) Following step 3), it is envisaged that the student will continue development of a 'smart' whole-body NMES device which will allow 'activation' of a large quantity of muscle mass. 6) Depending on the results from steps 1-5, as well as the student's interests and desired direction, a second human study could be performed to assess the impact of whole-body NMES on glycaemic control and clinical outcomes in ICU patients. Alternatively, they may focus on further prototype development (in collaboration with a department of Electrical Engineering, e.g. in Bath), with testing at Cardiff at key stages of development. Altogether, this truly multidisciplinary project will involve the development of expertise across biomechanics, medical engineering, and human muscle physiology to develop a 'smart' whole-body NMES device to improve outcomes of critically ill patients.
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