

DESIGN OF FORCE MEASUREMENT SYSTEM FOR PEDALING IN MR ENVIRONMENT

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ABSTRACT

People with stroke pedal asymmetrically. There may be differences in their brain activation during this asymmetric pedaling. Asymmetry in pedaling has yet to be measured in a magnetic resonance (MR) environment or during functional magnetic resonance imaging (fMRI). In order to evaluate the way stroke survivors pedal and their brain activation during lower limb pedaling tasks, we developed a device to measure asymmetry through force measurements. This device is a magnetic resonance compatible force transducer that is able to measure the force produced in real time from pedaling on a MR compatible pedaling device. This device will allow us to measure asymmetry in MR environments. The force transducer was designed to measure forces from both crank arms separately of the pedaling device. This is to detect the applied force differences between the two lower limbs while pedaling. This force transducer is based on a strain gauge Wheatstone bridge and designed to measure both small and large forces accurately (1.9-69N) as well as the fluctuation of the forces. The transducer uses fiber optics to transmit the data from the scanning room to the control room where the data can be recorded. Testing has shown that the force sensors are able to accurately measure force with high sensitivity and low hysteresis. Further testing will show that the MR environment will not affect the force measurements or vice versa. The device will be tested for accuracy in measuring asymmetries at different resistive loads.

Keywords: asymmetry, pedaling, force, MR, strain, gauge, fiber, optics, stroke

INTRODUCTION

Asymmetry in stroke survivors is prevalent. The primary functional movements and behaviors are completed by the non-paretic limb. For example, approximately 60% of the work for forward translation is generated by the non-paretic limb[1-3]. Asymmetric movements allow for stroke survivors to functionally move. These movements are a strategy for stroke survivors to get around paralysis or weakness in their affected limb in acute stages. The overuse and prolonged use of these strategies is associated with decreased movement of the paretic limb and limited recovery. This leads to a decreased quality of life in survivors[4-6]. Asymmetric movements are still persistent in chronic stroke even when the affected limb has improved motor function[7]. Functional movements of the lower limbs are typically bilateral in the cases of walking, standing, and pedaling. Pedaling as a technique for measuring coordination in stroke survivors can be used because mechanical work, forces, and phasing can be measured from a pedaling device. Pedaling devices outfitted with force sensing capabilities are made of metal and ferrous materials that make it impossible to use in a functional magnetic resonance imaging (fMRI) study.

Within our lab, a novel pedaling device was created for use in a fMRI study of bilateral versus unilateral locomotor control[8]. The device was created in such a way to make it entirely safe within or near an MRI machine. The device was made from plastic, acrylic, and wood making it safe for use in an MRI. The device being MR compatible allows for studies of lower limb pedaling while brain imaging. This pedaling device is able to record the position of its crank arms and the velocity at which the crank arms are moving during pedaling. This device is unable to measure forces against the pedals used for rotating the crank arms. Therefore, the aim of this study was to design and implement a force transducer that is MRI safe and is capable of measuring small and fast force variations accurately.