Data Collection for a Model of Muscle Fatigue during Dynamic Tasks of the Knee Joint

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Abstract

Experimental data is required to validate and/or tune a mathematical model to predict muscle fatigue in dynamic tasks. To this end, 40 participants were recruited to perform predefined exercises in a controlled environment. Data was collected through a Biodex System 3 dynamometer and EMG sensors attached to the superficial muscles of the quadriceps of the right knee. The subject was instructed to perform different exercises divided in static and dynamic activities. The tests were preceded by a rest period to allow for full muscle recovery. EMG, joint angle, angular velocity, and torque data were collected throughout the duration of the activities.

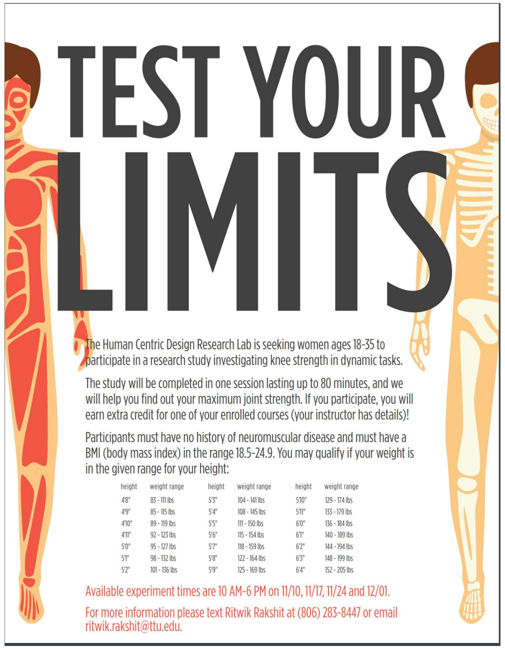
Introduction

How can muscular fatigue in dynamic tasks be predicted via a mathematical model?

The goal of this research is to develop a general model of muscular fatigue that can predict fatigue for every activity type, as opposed to current models that can only be applied to static exercises. In this study we collected kinematic and dynamic data for repeated flexion/extension cycles of the knee joint, and this data will be used to validate a fatigue model for repetitive dynamic knee extension

Equipment used

- Biodex System 3 dynamometer chair
- Electromyography (EMG) sensors
- Measuring tape
- Permanent marker
- 91% isopropyl alcohol
- Groomer
- 240 grit sandpaper



The Human Centric Design Research Lab is seeking women ages 18-35 to participate in a research study investigating knee strength in dynamic tasks.

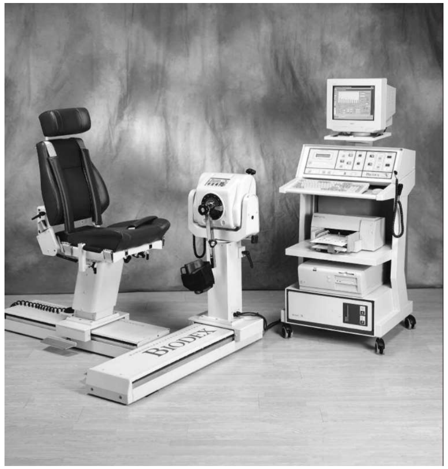
The study will be completed in one session lasting up to 80 minutes, and we will help you find out your maximum joint strength. If you participate, you will earn extra credit for one of your enrolled courses (your instructor has details)!

Participants must have no history of neuromuscular disease and must have a BMI (body mass index) in the range 18.5-24.9. You may qualify if your weight is in the given range for your height:

height	weight range	height	weight range	height	weight range
4'8"	83 - 111 lbs	5'3"	104 - 141 lbs	5'10"	129 - 174 lbs
4'9"	85 - 115 lbs	5'4"	108 - 145 lbs	5'11"	133 - 179 lbs
4'10"	89 - 119 lbs	5'5"	111 - 150 lbs	6'0"	136 - 184 lbs
4'11"	92 - 123 lbs	5'6"	115 - 154 lbs	6'1"	140 - 189 lbs
5'0"	95 - 127 lbs	5'7"	118 - 159 lbs	6'2"	144 - 194 lbs
5'1"	98 - 132 lbs	5'8"	122 - 164 lbs	6'3"	148 - 199 lbs
5'2"	101 - 136 lbs	5'9"	125 - 169 lbs	6'4"	152 - 205 lbs

Available experiment times are 10 AM-6 PM on 11/10, 11/17, 11/24 and 12/01.

For more information please text Ritwik Rakshit at (806) 283-8447 or email ritwik.rakshit@ttu.edu.



Research methodology

The data was collected from September to November 2019 in a laboratory equipped with the dynamometer system inside the Kinesiology building. For every experiment day, six subjects were scheduled.

To start, weight and height of each subject was taken. The subject was then placed in the dynamometer chair and the knee was loosely attached in a 15-degree angle to place the EMG sensors. The sensors were placed in the three superficial muscles of the quadriceps in the right leg. To find the Rectus Femoris, Vastus Medialis, and Vastus Lateralis muscles, measurements of the subject's leg were taken using the measuring tape. Before attaching the sensors, the spots were marked, shaved and smoothed with the sandpaper. After that, the area was cleaned with alcohol and the sensors were placed using doble-faced stickers. The previous steps were done to avoid any interference with the sensors from the skin.

The experiment consisted of two different activities: static and isokinetic knee extensions. In the static exercise the only data was obtained from the EMG sensors. While the knee attachment was locked (no movement), the subject had to push in an upward direction for five second each time, with breaks of 60 seconds, for three repetitions. During the isokinetic test, EMG and dynamic data were simultaneously collected. The subject performed three sets of knee extensions with 20-minute breaks to have a recovery of the muscle before the next test. The number of repetitions were increasing with an increase of velocity, too ("lighter" feeling for the subject). In total, every experiment lasted for 1 hour and 20 minutes. The subject had a 5-minute recovery in the chair to avoid fallings due to a tired leg.

Conclusion

The research is currently ongoing, and the mathematical model is expected to be validated by the dynamic data gathered in this study. The model is anticipated to be able to predict muscular fatigue in dynamic activities. After the knee model is developed, we will collect data for other joints in the body.

References

(right picture) Biodex Medical Systems Inc., *System 3 Pro Application/Operation Manual,* I

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(left picture) Rakshit, Ritwik (2019) *Test your limits*

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