PRISM 2021 Project Abstracts

Faculty Mentor – Dr. Bob Blaisdell

Muscle fatigue during repeat sprint exercise

The purpose of this study will be to elucidate the effects of repeated sprint exercise on muscular fatigue for sport performance indices. Repeat sprint ability (RSA) has been defined as the ability to produce high power output work, recover, and then reproduce subsequent high power efforts. Possessing a superior RSA may be a deciding factor for success in many sports, but little is still known about the actual causes of fatigue during repeat sprint exercise. Fatigue can be defined as a reversible decrease in maximal power output, despite the ability to continue the specified task. This exercise-induced fatigue may be caused by a variety of reasons that range from first sprint power exhibited, nature of the task, and neural to peripheral factors. Therefore, fatigue, specifically experienced during repeated sprint exercise is complex, at best. Consideration of neural factors commonly leads to examination of surface electromyography (EMG) and whether the ability to activate working muscles is still present as a result of fatigue. Several studies have reported decreases in mechanical scores as well as amplitude of EMG signals, which has been evident at fatigue levels greater than 10%decrement.Withstill no clear explanation of the mechanisms that limit repeat sprint performance, we have garnered understanding that RSA deteriorates substantially with fatigue development. More study is needed to continue the exploration into this fascinating phenomenon. This research will be an attempt to better understand the role of RSA and resulting fatigue in athlete performance and the mechanisms responsible for such.

Faculty Mentor – Dr. Kathy Gee

Assessing the Impacts of Climate Change on the Performance of Rainwater Harvesting Systems

Climate change is expected to alter the intensity, duration and frequency of precipitation events worldwide. Variations in rainfall patterns have the potential to impact water resources in several ways. An increase in extreme precipitation events will likely reduce the effectiveness of urban drainage systems in conveying and mitigating stormwater runoff. Areas predicted to experience less precipitation and increased drought conditions will need to reduce public water supply demands and perhaps even augment their current water source(s).

Rainwater harvesting systems (RWHs) are able to help mitigate some of these impacts of climate change. When designed properly, they can reliably serve as an alternative water supply source as well as a stormwater control measure. However, it is important to understand how climate change will impact the performance of these systems so that system designs can be modified accordingly to ensure adequate performance with respect to both water conservation and stormwater mitigation objectives.

The purpose of this study is to evaluate how the performance of RWHs in the United States may change due to changing rainfall patterns. RWH performance will be modeled for approximately 30 locations throughout the United States using both historical and projected rainfall data for varying climate change scenarios. Comparisons will be made between the historical and near-future results to determine the impact of climate change on RWH performance with respect to water conservation and stormwater management. Additionally, design recommendations will be created to maximize the ability of these practices to mitigate the impacts of climate change on water resources.

Faculty Mentor – Dr. Adam Franssen

Epigenetically Heritable Effects of Maternal Behavior in Rats

Previous research has shown dramatic changes in the rat brain following pregnancy, parturition, and motherhood (e.g., Kinsley et al., 2008). These neurological changes result in improved spatial memory, improved non-spatial memory, improved foraging ability (Kinsley et al., 2014), decreased anxiety (Massimo et al., 2011), reduced depression (Pawluski et al., 2016), and improved recovery from brain injuries compared to non-mothers (Franssen et al., 2012). Separately, research has demonstrated that "good" mothers raise calm pups that grow to become good mothers whereas "bad" mothers raise anxious pups that grow to become bad mothers (e.g. Weaver et al., 2004). Interestingly, the transgenerational transmission of anxiety and maternal skill appears to be epigenetic rather than genetic (e.g. Champagne and Curley, 2009). This PRISM program will work to combine these two findings. We know that "good" moms raise pups to be good moms (and vice versa) and we know that moms are better at behavioral tasks than non-moms. But are moms that were raised by "good" moms better at behavioral tasks than moms that were raised by "bad" moms? The student(s) working on this PRISM project will answer that question by comparing the pups of "good" and "bad" mother rats on a battery of behavioral tasks: the Elevated Plus Maze (anxiety), Forced Swim Test (depression), a modified Morris Water Maze (spatial memory), and a Novel Object Preference Test (non-spatial memory). Based on previous work, we hypothesize that maternal behavior will affect a wider range of adult behaviors than previously reported.

Faculty Mentor – Dr. Jeff Ledford

Excursions in Summation

We get our first exposure to summation formulae in Calculus II, where we learn for instance that

$$\sum_{j=1}^{N} j = \frac{N(N+1)}{2}.$$

This information helps us transition from a Riemann sum to an integral. We can find simple looking sums all over approximation theory. This project investigates the properties of one such `simple' sum of the form

$$\sum_{j=1}^{N} (-1)^j \binom{N}{j} j^{N+k},$$

where $k = 1, 2, 3, \ldots$ Cases for which a formula is known include only $k = 0, 1$, and 2. Our study hopes to close the information gap in a few ways. First, we wish to generate a summation formula in terms of N and k. This will involve studying series in greater detail than was possible in Calculus II. Secondly, we wish to develop the interplay between the sum and the parameter r in the general multiquadric $(1+x^2)^r$. These sums appear in non-local approximation schemes for the multiquadric, but almost nothing else is known about the relationship between N, K, and r.

Faculty Mentor – Dr. Jonathan White

Derivatization of a choline-appended Pt anticancer therapeutic and characterization of its cellular targets

Cancerous cells are characterized by numerous metabolic re-programming events, and many of these phenotypes have been utilized as avenues for targeted drug therapies. In cancers, oncogenes are overexpressed that are crucial for the uptake of choline. Despite a majority of cancers expressing enhanced choline uptake, relatively little effort has explored potential avenues for "hijacking" choline metabolism for targeted therapies. Such strategies might utilize small-molecule drugs covalently tethered to a quaternary ammonium cation, mimicking the structure-function relationship of choline and enhancing cellular uptake in tumor cells. Currently, a mainstay of small-molecule anticancer therapeutics remains the platinum-based drugs. Many cationic Pt complexes have been generated from modifying existing drugs in order to improve solubility and enhance delivery and target binding; however, none of these compounds have demonstrated superior efficacy in vivo. We have synthesized a novel, hybrid cationic Pt compound—a choline-conjugated Pt(II) compound—incorporating the potential cancer cell targeting of choline metabolites and enhanced solubility and target binding of a cationic Pt complex. This work will characterize the target binding of this compound to known cellular targets of Pt in vitro, and begin investigating its toxicity in cell cultures. We will quantify cellular toxicity using S. cerevisiae as a model organism and compare the activity to unmodified Pt drugs. In addition, we will synthesize derivatives of our Pt–choline conjugate and similarly characterize their efficacy in order to better understand the structure-function relationships of Pt–choline cellular reactivity.