Summer Undergraduate Research Fellowship (SURF) USA

Effects of Single-Leg Fatigue on Muscle Force Production and Vertical Jump in Female Volleyball and Basketball Players

Student: Kelly R. Kaufmann

Faculty Mentor: Dr. Summer Cook

Department of Kinesiology: Exercise Science

Research Location: Robert Kertzer Exercise Physiology Laboratory

New Hampshire Hall, UNH Durham

***The following example SURF proposal has been adapted from a longer original proposal written by Kelly Kaufmann/Kinesiology: Exercise Science (Faculty Mentor: Summer Cook). The example has been modified and edited to fit the current, more concise SURF proposal guidelines.**

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Proposal prompts in blue are included for instructional purposes only, based on the SURF proposal guidelines. Applicants should not include these prompts when submitting a final application.

Project Summary (one page maximum, single-spaced)

1. Abstract (200 words maximum): concisely summarize your project and its goals

Muscle fatigue, a reduction in force production, commonly impairs athletic performance, but the physiological mechanisms are not fully understood. Emerging research explores crossover fatigue, where fatigue that is induced via exercise in one limb can impair the force produced in the contralateral non-exercised limb due to alterations in neural pathways. The investigation of crossover fatigue is essential for understanding how fatigue is modulated by the brain and spinal cord to aid in the understanding of fatigue and its prevention. This is especially important for collegiate female athletes who experience fatigue in volleyball and basketball as they perform several movements that require repeated unilateral force production. This study will induce unilateral fatigue in the dominant thigh leg muscles of female collegiate athletes and then evaluate force production, muscle activation, and vertical jump performance in the exercised and non-exercised limbs. It is hypothesized that force production, muscle activation, and vertical jump height will decrease the greatest in the exercised limb, but the non-exercised limb will experience significant decrements as well.

2. Outcomes (list 2-5, one bullet point each): tangible products of your project (e.g. report, database, results of quantitative/qualitative/textual analysis, paper, thesis, presentation, production, exhibition, film, article submitted for conference or publication, etc.); also include at least one outcome stating how this project contributes to your personal, educational, and/or professional goals

- Produce dataset for absolute and relative fatigue using data from 15 recruited participants
- Data analyses (using ANOVA) for MVC, EMG, and fatigue protocol/vertical jumps
- Integrate research results into my Honors Thesis, present at the Undergraduate Research Conference and CHHS Grimes Award Competition, and write manuscript for publication in a peer-reviewed journal
- Apply my increased understanding of the mechanisms of fatigue toward my future goals: pursuing a Master's degree, attaining my Personal Training certification, and becoming a volleyball coach.

3. Timetable (one line or row per week maximum): using bullet points or a table, list your planned research activities and specific goals for each week of the project

Pre-SURF	Apply for IRB, practice methods, pilot test, obtain IRB, recruit	
Week 1	Familiarization: Participants 1-4	Testing session: Participants 1-4
Week 2	Familiarization: Participants 5-8	Testing session: Participants 5-8
Week 3	Familiarization: Participants 9-12	Testing session: Participants 9-12
Week 4	Familiarization: Participants 13-15	Testing session: Participants 13-15
Week 5	Overflow weeks for any participants not completed; begin data analysis	
Week 6	Data analysis: calculate absolute and relative fatigue of fatigue protocol	
Week 7	Data analysis: MVC torques, calculate percent decrement	
Week 8	Data analysis: EMG data from MVCs and fatigue protocol	
Week 9	Data analysis: EMG data from vertical jumps; begin ANOVA	
Week 10	Complete data analysis	

Project Background (two pages maximum, single-spaced)

1. **Project History and Significance**
   - general problem, theme, or issue to be addressed
   - historical context: i.e., most relevant previous research, scholarship, or artistry on this topic by other researchers, scholars, or artists (cite sources)
   - project's specific question, hypothesis, or objective
   - contribution of your project to the problem and your field
   - broader significance or importance of your research (e.g., social, cultural, intellectual, creative, practical, theoretical)

Fatigue of a single limb can have detrimental effects by decreasing athletic performance and limiting daily tasks (1). However, the effect of unilateral fatigue on non-exercised limbs (crossover fatigue) still needs to be understood. The existing literature on crossover fatigue presents conflicting results, with some studies showing evidence of a crossover effect while others do not (2). It has been observed that the effects of fatigue also vary between males and females (3), yet only one known study has examined crossover fatigue in collegiate female athletes (4). Therefore, the purpose of this study is to investigate the effect of a unilateral knee extension (KE) and knee flexion (KF) fatiguing protocol on force production, muscle activation, and vertical jump performance of the exercised and non-exercised leg in female collegiate athletes to determine if there is evidence of a crossover effect. We hypothesize that strength, muscle activation, and vertical jump performance will decrease in both the exercised and non-exercised limb after a unilateral fatiguing protocol. Not only will this provide information on the mechanisms of fatigue in female athletes to optimize their training, but it will also provide insight into how force production relates to performance.

2. **Approach and Methodology**
   - methods, theories, procedures, or lines of thinking and/or creating you will use to address your research topic and answer the question(s) you pose
   - if you plan to conduct interviews or surveys: what assumption/hypothesis/general principle you will test; the number of participants you will seek and how you will recruit/select them; sample interview/survey questions (to be included in Appendices)
   - materials and sources needed to pursue your project
   - how you will analyze, interpret, and/or evaluate your findings – including how/why this mode of analysis will enable you to accomplish your project objectives and/or answer your research question(s)
   - foreseeable challenges, obstacles, or difficulties – and how you are prepared to address them

This study will consist of 15 healthy female NCAA Division I collegiate volleyball and basketball players, recruited by word of mouth or via social media. Participants will receive $30 Amazon gift cards to compensate them for two visits: a familiarization visit and a fatigue protocol/testing visit. During the familiarization, participants will practice single-leg vertical jumps on each leg using the Vertec (Figure 1). Participants will then be seated in the Cybex Humac Norm isokinetic dynamometer (Figure 2) and will perform 3-5 unilateral isometric KE and KF maximum voluntary contractions (MVC) on each leg. The KE movement tests the strength of the quadriceps and the KF movement tests the strength of the hamstrings. They will also perform 10 isokinetic repetitions of KE and KF to become familiar with the unilateral exercise protocol. During the fatigue protocol/testing, participants will be prepped for electromyography (EMG) (Figure 3), as this will be used to measure the electrical activity of one of the quadriceps muscles (vastus lateralis) and the hamstrings muscles of each leg during all MVCs, the fatigue protocol, and vertical jumps. Participants will begin testing by standing flat

on the ground with their arms stretched as high as possible to obtain a standing reach height, and then they will perform unilateral vertical jumps on the dominant and non-dominant leg using a Vertec. Three trials will be taken for each jump, and the highest jump height will be recorded. Next, seated in the dynamometer, participants will perform three isometric KE and KF MVCs on the dominant and non-dominant legs. Participants will then perform the fatigue protocol which will consist of 5 sets of 30 consecutive isokinetic concentric KE and KF contractions on the dominant leg at 180° s^{-1}, with one minute of rest between each set. At the completion of the fatigue protocol, participants will immediately perform isometric KE and KF MVCs on the dominant leg and then the non-dominant leg as the post-fatigue measure. They will then perform one unilateral vertical jump on each leg using the Vertec, with the order of jumps randomized.

Data collected from the dynamometer is interfaced with the BIOPAC Systems MP 160 Receiver, and dynamometer data is analyzed using AcqKnowledge 5.0 computer software to produce torque curves (Figure 4). To quantify fatigue, the sum of 29 peak torques of each set of the fatigue protocol will be quantified. Relative fatigue will be determined by calculating the difference between the absolute fatigue of each set and set one, then dividing by the absolute fatigue of set one. Percent decrement in MVC of KE and KF from pre- to post-fatigue will also be calculated. Vertical jump height will be calculated by subtracting standing reach height from maximum vertical jump height. EMG data will be collected using the BioNomadix 2CH Wireless EMG Amplifier with a gain of 2000, bandlimited from 5.0 Hz to 500 Hz, and analyzed using the BIOPAC MP160 data acquisition system. Data will be analyzed using Analysis of Variance with repeated measures to compare the independent variables of fatigue condition (pre-fatigue, post-fatigue) and limb (exercised, non-exercised), and the dependent variables of MVC torque production, vertical jump height, and muscle activation from EMG.

3. My Role/Preparation/Experience

- your preparation and qualifications to undertake the project (e.g., previous coursework, jobs, extracurricular experiences, other research or training)
- your plans for further preparing yourself before undertaking the project, prior to the start date
- your unique role in the project as compared to the role of your faulty mentor and others (graduate students, technicians, collaborators), including your plan for regular communication with your mentor
- if a group project, the unique role of each student on the project (use an additional paragraph if necessary for this question)

As a volleyball player for UNH, I have both seen and experienced the physical and psychological effects of fatigue, which has led to my interest in and development of this research study. Taking EXSC 621: Exercise Laboratory Techniques last spring helped me become familiar with executing the scientific method, formulating research questions, and interpreting scientific literature. We performed labs investigating fatigue, so I am familiar with using the Humac Norm dynamometer and analyzing its data. Additionally, the information learned from BMS 507 and 508: Human Anatomy and Physiology and EXSC 620: Exercise Physiology ensures that I have a great foundation for the relevant physiology and anatomy. I am able to complete the data analysis after taking PSYC 402: Statistics in Psychology, but I will work with Dr. [A] to learn how to analyze the data using SPSS software. I am also taking INCO 490A: Fundamentals of Research Ethics with Dr. [A] this semester, and I have completed all the web-based training modules in the UNH Responsible Conduct of Research program. Dr. [A] and I have been meeting weekly during the spring semester as we are currently pilot testing the study methods during my free time. Once the methods are solidified, Dr. [A] and I will apply for IRB approval and continue practicing the methods in the lab.

Appendices

Works Cited

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2. Halperin I, Chapman DW, Behm DG. Non-local muscle fatigue: effects and possible mechanisms. European Journal of Applied Physiology. 2015; 115(1 0):2031—48.
3. Hunter SK. Sex differences and mechanisms of task-specific muscle fatigue. Exercise and Sport Sciences Reviews. 2009;37(3):113—22.
4. Mclean SG, Samorezov JR. Fatigue-Induced ACL Injury Risk Stems from a Degradation in Central Control. *Medicine & Science in Sports & Exercise*. 2009;41(8):1661-72.

Works Consulted

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Martin PG, Rattey J. Central fatigue explains sex differences in muscle fatigue and contralateral cross-over effects of maximal contractions. Pfiugers Archiv - European Journal of Physiology. 2007;454(6):957—69.

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Rattey J, Martin PG, Kay D, Cannon J, Marino FE. Contralateral muscle fatigue in human quadriceps muscle: evidence for a centrally mediated fatigue response and cross-over effect. Pfiugers Archiv - European Journal of Physiology. 2006;452(2):199—207.

Santana JC. Single-Leg Training for 2-Legged Sports: Efficacy of Strength Development in Athletic Performance. Strength and Conditioning Journal. 2001;23(3):35—7.

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Zeleznilc P, Slak V, Kozinc Z, arabon N. The Association between Bilateral Deficit and Athletic Performance: A Brief Review. Sports. 2022;10(8):112.

Figure 1. Demonstration of vertical jump set up on the Vertec.

Figure 2. Set up and subject positioning on the Cybex Humac Norm dynamometer.

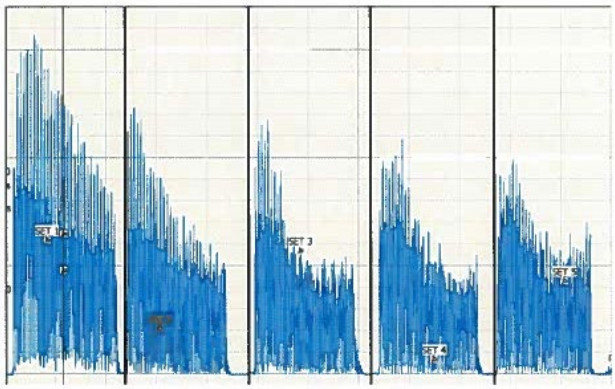

Figure 3. Leg positioning and EMG electrode placement while in the Cybex Humac Norm dynamometer.

Figure 4. KE and KF torque curves for 5 sets of 30 repetitions of exercise assessed in AcqKnowledge 5.0 software. Note the reduction of maximum torque (fatigue) over the 5 sets.