IRGF Final Report
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Project Title: The Efficiency of Performing Mechanical Joint Work in Vivo

1.1 Project Summary

We investigated the energy cost and mechanical efficiency of performing fixed amounts of work at the knee compared to the ankle. We demonstrate that, contrary to current dogma, the knee extensor muscles are not less efficient than the ankle plantarflexor muscles. This contradicts important proposed mechanisms for why the energy cost of exercise progressively increases throughout the duration. We explain, through an integrative biomechanics and physiological perspective, how changes in joint work might impact the energy cost of single joint and whole-body energy cost.

1.2 Student involvement

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1.3 Dissemination and Knowledge Mobilization

To date, we have presented this work at the 2025 International Society of Biomechanics conference (Stockholm, July 2025) and recently as an invited speaker at the University of Calgary's musculoskeletal seminar series. The student co-investigator will also be presenting her results at the 2026 World Congress of Biomechanics (Vancouver, July 2026) and the 2026 Canadian Society of Exercise Physiology conference (Edmonton, October 2026).

1.4 Project Outcomes and Impacts

The present proposal aims to fill this gap by simultaneously measuring whole body Ec, via indirect calorimetry, joint level mechanical work, using 3D motion capture and inverse dynamics, and muscle level energetics, via ultrasound based fascicle tracking and surface EMG, during a prolonged, constant speed treadmill run. By quantifying how ankle, knee and hip work contributions and relating these changes to real time Ec, we will determine whether the distal to proximal shift causally drives the progressive rise in running energy expenditure. This knowledge will clarify the mechanistic underpinnings of the Ec of running and may inform training or footwear interventions aimed at preserving ankle work and limiting unnecessary metabolic penalties. Understanding the link between joint work redistribution and Ec could explain why some elite runners maintain superior economy despite similar $\dot{V}O_2max$, and why fatigue resistant footwear or conditioning strategies sometimes fail to offset the cost of distal to proximal work shift. Ultimately, the findings could guide targeted neuromuscular training, fatigue management protocols, or device designs that preserve ankle work, thereby enhancing endurance performance. This study is ongoing, and is currently being funded by the Canada Research Chairs program and NSERC.