MUSCLE OXYGEN SATURATION AS A BIOMARKER TO GUIDE RETURN TO PLAY AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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Introduction

Return to play (RTP) protocols for anterior cruciate ligament (ACL) injuries involve full motion, strength, psychological readiness, GPS monitoring, isokinetic testing, and functional testing. However, current RTP criteria lack objective, internal, and continuous data necessary to complement current assessments. The ACL is crucial in stabilization, motion, and preventing internal rotation of the knee joint [1]. ACL ruptures cause increases up to 10-15 mm of anterior tibial translation at 30° of knee flexion [1]. Monitoring muscle oxygen saturation (SmO_2) levels utilizing wearable sensors enables the collection of continuous, internal, and objective data to monitor O_2 delivery and consumption in the surgical and contralateral limbs. Measurement and integration of digital biomarkers such as SmO_2 into electronic health records of athletes have the potential to compliment current rehabilitation exercises and therapies used during the RTP period [2], [3]. We hypothesize that muscle atrophy in the surgical leg post ACL reconstruction (ACLR) causes changes in SmO_2.

Methods

Currently ongoing is a multi-arm IRB approved study (20191389) assessing SmO_2 levels in the legs of healthy subjects (arm 1, n=50) and patients after ACLR (arm 2, n=50). Inclusion criteria involved participants being 14-22 years of age, have no history of prior ACLR, knee arthroscopic surgery, or hip arthroscopic surgery, and not pregnant. A standardized workout was created for testing at 6-, 9-, and 12 -months post ACLR. Sensors are placed on the vastus medialis (VMO) bilaterally using medical grade adhesives to record SmO_2. Healthy patients undergo testing once, while surgical patients undergo the testing at 6-, 9-, and 12-months post-operatively.

Results

Representative SmO_2 data recorded from a patient (21-year-old, female football athlete, outside-forward) after ACLR demonstrated a statistically significant difference in contralateral versus surgical limb average muscle oxygen saturation in the Tabata, leg press, and max-minute exercises at 6- and 9-month trials (Figure 1). There were no significant differences found between surgical and contralateral limbs during the leg press and max-minute exercises at the 12-month trial. The mean difference significantly decreased for the Tabata, leg press, and max-minute exercises between each visit from the 6 to 12-month period with r^2 values of 0.8656, 0.8163, and 0.8891, respectively. ACLR SmO_2 levels at the 12-month trials resembled the healthy cohort (not shown).

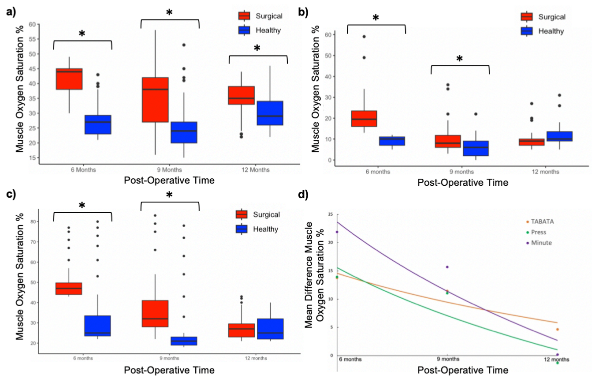

*Figure 1: SmO_2 data of patient's contralateral and surgical limbs at 6-, 9-, and 12-months post-operation. (a) Tabata fan bike exercise. (b) Bilateral leg press exercise. (c) Max-minute fan bike exercise. (d) Mean difference in SmO_2 for Tabata, leg press, and max-minute exercises. *denotes $p < 0.05$ compared to healthy and surgical limbs.*

Discussion

The change in SmO_2 in ACLR patients is likely due to a combination of altered hemoglobin-oxygen unbinding, altered blood delivery, detraining, and muscle atrophy. These changes in SmO_2 in the ACLR subjects correlate with improvement in other RTP testing. SmO_2 data offers complementary, internal, and objective data in RTP criteria. Future work will enable the development of an integrative algorithm that physicians and physical therapists can employ to gauge athlete readiness following ACLR with broader implications to other musculoskeletal injuries.

References

1. Domnick et al, World Journal of Orthopedics, 7(2): 82-93, 2016.
2. Seshadri et al, npj Digital Medicine, 2(72), 2019.
3. Seshadri et al, Front. Sports Act. Living, 2, 2020.

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