Shear Wave Speed versus Knee Extensor Torque during Maximum Voluntary Isometric Contraction (MVIC) post-Anterior Cruciate Ligament Reconstruction (ACLR) using Bone-Patellar Tendon-Bone (BPTB) Autograft

Naoaki Ito[1], Elizabeth A. Schmida[1], Darryl G. Thelen[1], Bryan C. Heiderscheit[1]
[1]University of Wisconsin – Madison (UW), WI, USA
Email: ito@ortho.wisc.edu

Summary

Patellar tendon load quantified via shear wave tensiometry (SWT) had excellent agreement with knee extensor torque during MVIC in a small cohort of athletes after ACLR. SWT may have the potential to be used in rehabilitation to optimize dosing for exercises targeted at knee extensor loading.

Introduction

Knee extensor mechanism loading is a key component of rehabilitation after ACLR [1] but finding the best approach to optimize loading via exercise remains a challenge. This is partly due to compensatory movement patterns commonly seen after injuries leading to a disconnect between internal (i.e., muscle-tendon force) and external (i.e., weight moved) load. SWT is an emerging wearable technology [2] with the potential to improve precision in dosing exercises during rehabilitation by directly assessing tendon load. SWT, however, has yet to be tested over the graft site patellar tendon that are known to have persistent structural alterations [3]. The purpose was to evaluate the agreement in patellar tendon load and knee extensor torque after ACLR using BPTB autograft.

Methods

Four athletes (**Table 1**) with a history of ACLR performed MVIC testing on an electromechanical dynamometer (Biodex System 4) in 60° of knee flexion. A tensiometer secured over the patellar tendon was used to simultaneously measure wave speeds. The trial with the highest peak torque was used for analysis. The torque waveform was normalized to 100% MVIC for comparison across participants and limbs. Waveforms were analyzed when torque exceeded 20% of MVIC. Shear wave speed squared (SWS^2), which varies in proportion to axial stress [2], was calculated and normalized to the SWS^2 value at the time of MVIC. The coefficient of determination (R^2) and root mean square error (RMSE) between the waveforms were calculated for each trial.

Results and Discussion

Excellent agreement with minimal RMSE was seen for most trials and for both limbs (**Figure 1**), indicating that SWT may be used to measure knee extensor load after ACLR using BPTB autograft. Some discrepancy in waveform shape and magnitude towards the beginning and end of the trials was seen. This may be a result of delay in torque detection by the dynamometer due to inertia and dynamics of the dynamometer system. The discrepancies may also arise from hamstring co-contraction patterns, which would affect the net torque but not be reflected in patellar tendon load. Results are promising, however, further testing of SWT is necessary.

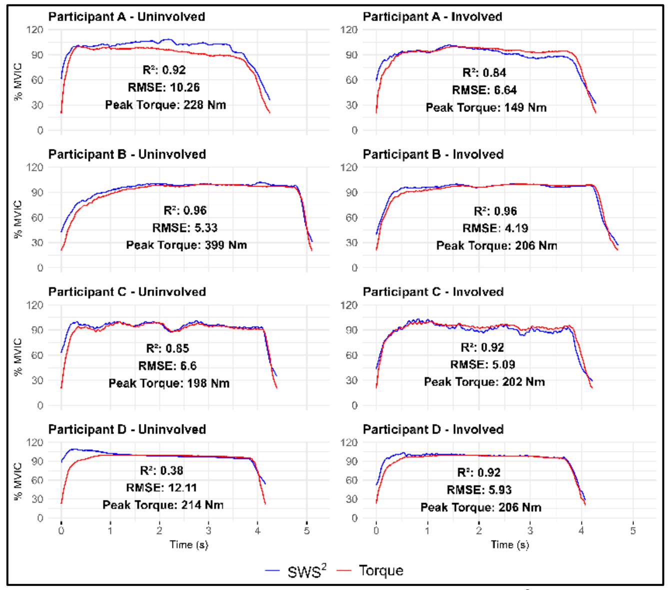

Figure 1: Agreement in waveforms between SWS^2 and knee extensor torque during MVIC for each participant and by limb

Conclusions

SWT may be used as a tool to capture isometric knee extensor load after ACLR using BPTB autografts. Investigating the application of SWT across various exercises may contribute to improvements in precise dosing during rehabilitation.

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References

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[2] Martin J et al. (2018) *Nat Commun,* **9(1)**: 1592.
[3] Ito et al. (2024) *J Orthop Res.,* **42(7)**: 1399-1408.

Table 1: Demographics of the four participants included in this study

Participant	Sex	Age (years)	Height (m)	Weight (kg)	Time since surgery (months)	International Knee Documentation Committee (IKDC)
A	**Female**	**24**	**1.64**	**68**	**13.8**	**70**
B	**Male**	**20**	**1.90**	**94**	**7.6**	**83**
C	**Female**	**22**	**1.58**	**70**	**63.0**	**83**
D	**Female**	**25**	**1.59**	**65**	**99.4**	**86**