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Scriptwriter Name: Poornima G

Project Page Link: <https://review.jove.com/account/file-uploader?src=21986888>

Title: Quantifying Recovery After Anterior Cruciate Ligament Reconstruction Using the Torque- Velocity Relationship

Authors and Affiliations:

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Author Questionnaire

- 1. Microscopy:** Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**
- 2. Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **Yes**
- 3. Filming location:** Will the filming need to take place in multiple locations? **No**
- 4. Testimonials (optional):** Would you be open to filming two short testimonial statements **live during your JoVE shoot**? These will **not appear in your JoVE video** but may be used in JoVE's promotional materials. **Yes**

Current Protocol Length

Number of Steps: 25

Number of Shots: 55

Interviews

Videographer: Obtain headshots for all authors available at the filming location.

Authors: Please note that **the questions will not appear on screen**. Please answer in **stand-alone full sentence with sufficient context**

We have chosen the 5 best answers

INTRODUCTION:

~~REQUIRED: Summarize your research focus and the main questions it aims to answer.~~

- 1.1. **Xavier Thompson:** My research focuses on how muscle function changes following anterior cruciate ligament reconstruction. My goal is to reduce the risk of reinjury.
 - 1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~Describe the research gap or limitation in existing methods and how this protocol addresses them.~~

- 1.2. **Xavier Thompson:** Most of the current testing focuses on assessing maximal strength, but does not capture changes in other muscular capabilities.
 - 1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

CONCLUSION:

~~What does this protocol allow researchers to study or measure?~~

- 1.3. **Xavier Thompson:** This protocol allows researchers to quantify the torque-velocity relationship of the quadriceps following ACL reconstruction.
 - 1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~Are there any additional methods or analyses that can be performed following this procedure?~~

1.4. **Xavier Thompson:** This procedure focuses on peak torque expression across velocities, but additional analyses of torque time curves can be performed.

1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~How can future studies build on this work? Describe the questions or research directions that can be investigated next.~~

1.5. **Xavier Thompson:** Future studies should continue to evaluate how the full torque-velocity relationship affects patient function and recovery.

1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

Videographer: Obtain headshots for all authors available at the filming location.

Testimonial Questions (OPTIONAL):

Videographer: Please capture all testimonial shots in a wide-angle format with sufficient headspace, as the final videos will be rendered in a 1:1 aspect ratio. Testimonial statements will be presented live by the authors, sharing their spontaneous perspectives.

- Testimonial statements will **not appear in the video** but may be featured in the journal's promotional materials.
- **Provide the full name and position** (e.g., Director of [Institute Name], Senior Researcher [University Name], etc.) of the author delivering the testimonial.
- Please **answer the testimonial question live during the shoot**, speaking naturally and in your own words in **complete sentences**.

What problem in your field of research does your JoVE article address?

- 1.6. **Xavier Thompson, Assistant Professor of Sports Science, Louisiana State University:**
(authors will present their testimonial statements live)

1.6.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

What value do you expect this video article to have for other researchers working in your field?

- 1.7. **Xavier Thompson, Assistant Professor of Sports Science, Louisiana State University:**
(authors will present their testimonial statements live)

1.7.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

Ethics Title Card

This research has been approved by the Institutional Review Board (IRB) at Louisiana State University

Protocol

***Videographer:** Please always record an audio slate while filming each shot mentioned in the shotlist.*

2. Participant Preparation and Dynamometer Setup

Demonstrator: Xavier Thompson

- 2.1. To begin, explain the procedure to the participant who underwent anterior cruciate ligament reconstruction at least 4 months earlier [1]. Have the participant complete a standardized warm-up consisting of approximately 5 minutes of treadmill walking at a pace of 3 miles per hour [2].
 - 2.1.1. WIDE: Talent explaining the procedure to the participant. ***Videographer:** Please obtain CU shot as well for this shot.*
 - 2.1.2. Participant walking on the treadmill at 3.0 miles per hour.
- 2.2. Turn on the dynamometer [1] and attach the dynamometer arm [2].
 - 2.2.1. Talent turning on the dynamometer.
 - 2.2.2. Talent attaching the dynamometer arm.
- 2.3. Position the chair at a back angle of 85 degrees [1]. Set the dynamometer rotation to 40 degrees, according to the manufacturer's recommendations [2].
 - 2.3.1. Talent adjusting the chair back angle to 85 degrees.
 - 2.3.2. Talent setting the dynamometer rotation to 40 degrees.
- 2.4. Then, start the testing procedure with the uninvolved limb [1]. Seat the participant with the hips flexed to approximately 85 degrees [2]. Instruct the participant to maintain an upright posture [3] and to avoid grabbing the dynamometer handles during testing [4].
 - 2.4.1. Talent examining/pointing to the participant's unaffected limb.
 - 2.4.2. Talent seating the participant with the hips flexed to approximately 85 degrees.
 - 2.4.3. Talent instructing the participant to maintain an upright posture.
 - 2.4.4. Talent instructing the participant to avoid grabbing the handles of the dynamometer by gesturing.

- 2.5. Adjust the back translation so that the popliteal fossa is positioned approximately 3 to 4 centimeters anterior to the edge of the seat [1].
 - 2.5.1. Talent adjusting the back translation to position the popliteal fossa approximately 3 to 4 centimeters anterior to the edge of the seat.
- 2.6. Then, adjust the chair position [1] and the dynamometer arm orientation until the mechanical axis aligns with the lateral femoral condyle [2]. Position the resistance pad approximately 5 centimeters proximal to the lateral malleolus on the anterior portion of the lower leg [3].
 - 2.6.1. Talent adjusting the chair position.
 - 2.6.2. Talent adjusting the dynamometer arm orientation to align the mechanical axis with the lateral femoral condyle.
 - 2.6.3. Talent positioning the dynamometer arm resistance pad approximately 5 centimeters proximal to the lateral malleolus on the anterior portion of the lower leg.
- 2.7. Secure the test limb to the dynamometer arm while maintaining the shank in a neutral position to prevent rotation [1]. Stabilize the participant using straps across the torso and the pelvis [2].
 - 2.7.1. Talent securing the test limb to the dynamometer arm while maintaining the shank in a neutral position.
 - 2.7.2. Talent applying straps across the torso and the pelvis to stabilize the participant.
- 2.8. Next, secure the test limb with a strap to prevent hip flexion [1]. Secure the contralateral limb using the available restraint [2]. Instruct the participant to only attempt extension and flexion of the test limb for the duration of the test [3].
 - 2.8.1. Talent securing the testing limb with a strap to prevent hip flexion.
 - 2.8.2. Talent securing the contralateral limb using a restraint.
 - 2.8.3. Talent instructing the participant to only attempt extension and flexion of the tested limb for the duration of the test.
- 2.9. Passively move the limb through a full range of motion arc to ensure that no additional adjustments are needed [1]. Record the chair position, the dynamometer position, and the arm length for future assessment [2].
 - 2.9.1. Talent passively moving the limb through a full range of motion arc.

- 2.9.2. Talent recording the chair position, the dynamometer position, and the arm length in a book.

3. Setting the Range of Motion

- 3.1. Set the anatomical zero at 180 degrees or full knee extension [1]. If the participant lacks full knee extension, use the dynamometer offset function to account for the limitation [2]. Enter the difference between the current limb position and the anatomical zero degrees into the dynamometer offset. Note that range-of-motion limitations may affect the waveform analysis and the peak torque angle [3].
 - 3.1.1. Talent setting the anatomical zero at 180 degrees or full knee extension.
 - 3.1.2. Talent using the dynamometer offset function to account for the limitation in full knee extension.
 - 3.1.3. Talent entering the difference between the current limb position and the anatomical zero degrees into the dynamometer offset.
- 3.2. Set the dynamometer limit of extension at 175 degrees, corresponding to 5 degrees of knee flexion from the anatomical zero or the maximum available knee extension [1].
 - 3.2.1. Talent setting the dynamometer limit of extension to 175 degrees.
- 3.3. Then, set the dynamometer limit of flexion at 70 degrees, corresponding to 110 degrees of knee flexion from the anatomical zero or the maximum available knee flexion if 110 degrees cannot be reached [1]. Adjust the manual stops accordingly [2].
 - 3.3.1. Talent setting the dynamometer limit of flexion to 70 degrees.
 - 3.3.2. Talent adjusting the manual stops on the dynamometer.
- 3.4. Measure the limb weight at 180 degrees if possible, or as close to the maximal knee extension as possible without compromising participant comfort [1]. Instruct the participant to relax [2]. Weigh the limb 3 to 4 times in quick succession until the weight appears stable [3].
 - 3.4.1. Talent positioning the limb for the limb weight measurement at or near the

maximal knee extension.

3.4.2. Talent instructing the participant to relax.

3.4.3. Talent performing repeated limb weight measurements until a stable value is obtained.

4. Strength Assessment: Isometric and Isokinetic Testing

Demonstrator: Xavier Thompson

4.1. Provide the standardized verbal instruction to kick as hard and fast as possible and then pull the leg back down as hard and fast as possible [1]. State that the participant should always be moving the machine, and the machine should not move them [2].

4.1.1. Talent providing the standardized verbal instruction to kick as hard and fast as possible with actions.

4.1.2. Talent explaining that the participant is always moving the machine with actions/gestures.

4.2. Begin the isometric knee extension test at a joint angle of 90 degrees of knee flexion, with 3 familiarization repetitions [1]. Instruct the participant to kick out and maintain a contraction at 25% of the perceived maximum [2]. Allow 30 seconds of rest between contractions [3]. Then, instruct the participant to kick out and maintain a contraction at 50% and then 75% of their perceived maximum [4]. Allow 30 seconds of rest between contractions. Provide strong verbal encouragement during all trials [5].

4.2.1. Talent asking the participant to perform the familiarization repetitions and the participant performing the action.

4.2.2. Participant maintaining a contraction at 25% of the perceived maximum.

4.2.3. Participant rests between contractions.

4.2.4. Participant maintaining a contraction at 50% of the perceived maximum.

4.2.5. Participant rests between contractions and the talent provides verbal encouragement to the participant.

4.3. Next, instruct the participant to kick out as hard and fast as possible and maintain the

contraction for 3 to 5 seconds [1].

4.3.1. Participant kicking out as hard and fast as possible and maintaining the contraction for 3 to 5 seconds.

4.4. Perform 2 to 3 maximal trials with 30 seconds of rest between trials [1].

4.4.1. Participant finishing another trial and then resting.

4.5. Instruct the participant to perform the concentric isokinetic knee extension and flexion test at 60, 180, and 240 degrees per second [1].

4.5.1. Talent instructs the participant on how to perform the concentric isokinetic knee extension and flexion test with actions/gestures.

4.6. At each velocity, perform 4 consecutive submaximal practice repetitions, progressing from low to near maximal effort at 25% to 75%. Then, perform 8 maximal effort repetitions [1].

4.6.1. Participant performing consecutive submaximal practice repetitions with progressively increasing effort. **Videographer's NOTE:** 4.6.1 includes sections of 4.8.1. With 4.8.1 being the rest period it was included in the production of 4.6.1

4.7. Provide real-time visual feedback displaying the torque versus time or torque versus position curves [1].

4.7.1. SCREEN: 72088_screenshot_1-(1).mp4 01:05-01:12.

4.8. Allow 30 to 60 seconds of rest between tests at each new velocity [1]. If the participant shows signs of excessive fatigue, increase the rest time according to the site-specific protocol [2].

4.8.1. Participant resting between tests at a new velocity.

4.8.2. Talent increasing the time on a timer.

4.9. Next, repeat the entire protocol on the anterior cruciate ligament reconstruction limb [1].

4.9.1. Participant performing the protocol on the other limb (anterior cruciate ligament reconstruction limb).

4.10. Instruct the participant to discontinue testing if the participant experiences sharp pain or discomfort [1].

4.10.1. Talent instructing the participant to discontinue testing if sharp pain or discomfort occurs with visual cues. **Videographer's NOTE:** 4.10.1 Was requested to be omitted by the Talent. Said it was already performed in 4.9.1. Add the footage of stopping the procedure from 4.9.1 and extend the footage for 4.10.1.

Results

5. Results

- 5.1. Successful completion of the protocol resulted in the highest torque output at 0 degrees per second [1] and a progressive decline in torque with increasing isokinetic contraction velocities [2].
 - 5.1.1. LAB MEDIA: Figure 2. *Video editor: Highlight the data points and the trend lines at 0 degrees per second across the panels where the values are highest.*
 - 5.1.2. LAB MEDIA: Figure 2. *Video editor: Sequentially highlight points at 60, 90, 180 and 270 degrees/s velocity.*
- 5.2. The anterior cruciate ligament reconstructed limbs demonstrated a flatter torque-velocity slope [1] than the contralateral limbs [2].
 - 5.2.1. LAB MEDIA: Figure 2. *Video editor: Highlight the gray trend line in the ACLR panel*
 - 5.2.2. LAB MEDIA: Figure 2. *Video editor: Highlight the gray trend line in the contralateral panel*
- 5.3. The representative dataset showed lower peak torque values in the involved limb than in the uninvolved limb across the testing velocities [1].
 - 5.3.1. LAB MEDIA: Figure 1. *Video editor: Show the graph and Highlight the blue “Peak Torque (Involved)” points.*
 - 5.3.2. LAB MEDIA: Figure 1. *Video editor: Show the graph and Highlight the orange “Peak Torque (Uninvolved)” points*
- 5.4. The representative dataset demonstrated a limb symmetry value of 82.65% [1].
 - 5.4.1. LAB MEDIA: Figure 1. *Video editor: Show the spreadsheet at the upper part only and highlight the cell containing the value “82.65” next to “Symmetry”.*

- 1. Anterior cruciate ligament
Pronunciation link: <https://www.merriam-webster.com/medical/anterior%20cruciate%20ligament>

- IPA: /æn'tɪriər 'kruːʃiət 'lɪɡəmənt/
Phonetic Spelling: an·TEER·ee·er KROO·shee·uht LIG·uh·muhnt
2. Reconstruction
Pronunciation link: <https://www.merriam-webster.com/dictionary/reconstruction>
IPA: /,ri:kən'strʌkʃən/
Phonetic Spelling: ree·kuhn·STRUK·shuhn
 3. Standardized
Pronunciation link: <https://www.merriam-webster.com/dictionary/standardize>
IPA: /'stændər,daɪzd/
Phonetic Spelling: STAN·der·dyzd
 4. Dynamometer
Pronunciation link: <https://www.merriam-webster.com/dictionary/dynamometer>
IPA: /,daɪnə'mɑːmətər/
Phonetic Spelling: DY·nuh·MAH·muh·ter
 5. Flexed
Pronunciation link: <https://www.merriam-webster.com/dictionary/flex>
IPA: /flekst/
Phonetic Spelling: flekst
 6. Popliteal
Pronunciation link: <https://www.merriam-webster.com/medical/popliteal>
IPA: /,pɑːplə'tiːəl/
Phonetic Spelling: pop·luh·TEE·uhl
 7. Fossa
Pronunciation link: <https://www.merriam-webster.com/medical/fossa>
IPA: /'fa:sə/
Phonetic Spelling: FAH·suh
 8. Mechanical
Pronunciation link: <https://www.merriam-webster.com/dictionary/mechanical>
IPA: /mə'kænɪkəl/
Phonetic Spelling: muh·KAN·ih·kuhl
 9. Femoral
Pronunciation link: <https://www.merriam-webster.com/medical/femoral>
IPA: /'femərəl/
Phonetic Spelling: FEM·uh·ruhl
 10. Condyle
Pronunciation link: <https://www.merriam-webster.com/medical/condyle>
IPA: /'kɑːndaɪl/
Phonetic Spelling: KON·dyle
 11. Proximal
Pronunciation link: <https://www.merriam-webster.com/medical/proximal>
IPA: /'prɑːksəməl/
Phonetic Spelling: PROK·suh·muhl
 12. Malleolus
Pronunciation link: <https://www.merriam-webster.com/medical/malleolus>

- IPA: /mə'li:ələs/
Phonetic Spelling: muh·LEE·uh·luhs
13. Contralateral
Pronunciation link: <https://www.merriam-webster.com/medical/contralateral>
IPA: /ˌkɑːntrə'lætərəl/
Phonetic Spelling: KON·truh·LAT·uh·ruhl
14. Anatomical
Pronunciation link: <https://www.merriam-webster.com/dictionary/anatomical>
IPA: /ˌænə'tɑːmɪkəl/
Phonetic Spelling: an·uh·TOM·ih·kuhl
15. Anatomical zero
Pronunciation link: No confirmed link found
IPA: /ˌænə'tɑːmɪkəl 'zɪroʊ/
Phonetic Spelling: an·uh·TOM·ih·kuhl ZEER·oh
16. Waveform
Pronunciation link: <https://www.merriam-webster.com/dictionary/waveform>
IPA: /'weɪv fɔːrm/
Phonetic Spelling: WAYV·form
17. Torque
Pronunciation link: <https://www.merriam-webster.com/dictionary/torque>
IPA: /'tɔːrk/
Phonetic Spelling: tork
18. Isometric
Pronunciation link: <https://www.merriam-webster.com/dictionary/isometric>
IPA: /ˌaɪsə'metɪk/
Phonetic Spelling: EYE·suh·MET·rik
19. Familiarization
Pronunciation link: No confirmed link found
IPA: /fə'mɪljərə'zeɪʃən/
Phonetic Spelling: fuh·MIL·yuh·ruh·ZAY·shuhn
20. Contraction
Pronunciation link: <https://www.merriam-webster.com/dictionary/contraction>
IPA: /kən'trækʃən/
Phonetic Spelling: kuhn·TRAK·shuhn
21. Maximal
Pronunciation link: <https://www.merriam-webster.com/dictionary/maximal>
IPA: /'mæksəməl/
Phonetic Spelling: MAK·suh·muhl
22. Concentric
Pronunciation link: <https://www.merriam-webster.com/dictionary/concentric>
IPA: /kən'sentrɪk/
Phonetic Spelling: kuhn·SEN·trik
23. Isokinetic
Pronunciation link: <https://www.merriam-webster.com/medical/isokinetic>

- IPA: /ˌaɪsoʊkəˈnɛtɪk/
Phonetic Spelling: EYE·soh·kuh·NET·ik
24. Velocity
Pronunciation link: <https://www.merriam-webster.com/dictionary/velocity>
IPA: /vəˈlɑːsəti/
Phonetic Spelling: vuh·LOSS·uh·tee
25. Fatigue
Pronunciation link: <https://www.merriam-webster.com/dictionary/fatigue>
IPA: /fəˈtiːɡ/
Phonetic Spelling: fuh·TEEG
26. Protocol
Pronunciation link: <https://www.merriam-webster.com/dictionary/protocol>
IPA: /ˈprəʊtəˌkɔːl/
Phonetic Spelling: PROH·tuh·kawl
27. Representative
Pronunciation link: <https://www.merriam-webster.com/dictionary/representative>
IPA: /ˌreprəˈzɛntətɪv/
Phonetic Spelling: rep·ruh·ZEN·tuh·tiv
28. Symmetry
Pronunciation link: <https://www.merriam-webster.com/dictionary/symmetry>
IPA: /ˈsɪmətri/
Phonetic Spelling: SIM·uh·tree
29. Isokinetic contraction
Pronunciation link: No confirmed link found
IPA: /ˌaɪsoʊkəˈnɛtɪk kənˈtrækʃən/
Phonetic Spelling: EYE·soh·kuh·NET·ik kuhn·TRAK·shuhn
30. ACLR
Pronunciation link: No confirmed link found
IPA: /ˌeɪ siː ɛl ˈɑːr/
Phonetic Spelling: AY·SEE·EL·AR