THE UNIVERSITY of TENNESSEE CHATTANOOGA

# MOTOR LEARNING STRATEGIES INCREASE INTRINSIC MOTIVATION AND QUADRICEPS TORQUE OUTPUT IN HEALTHY INDIVIDUALS

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# Disclosures

The authors have no conflicts of interest and nothing to disclose.

# Introduction - The Problem

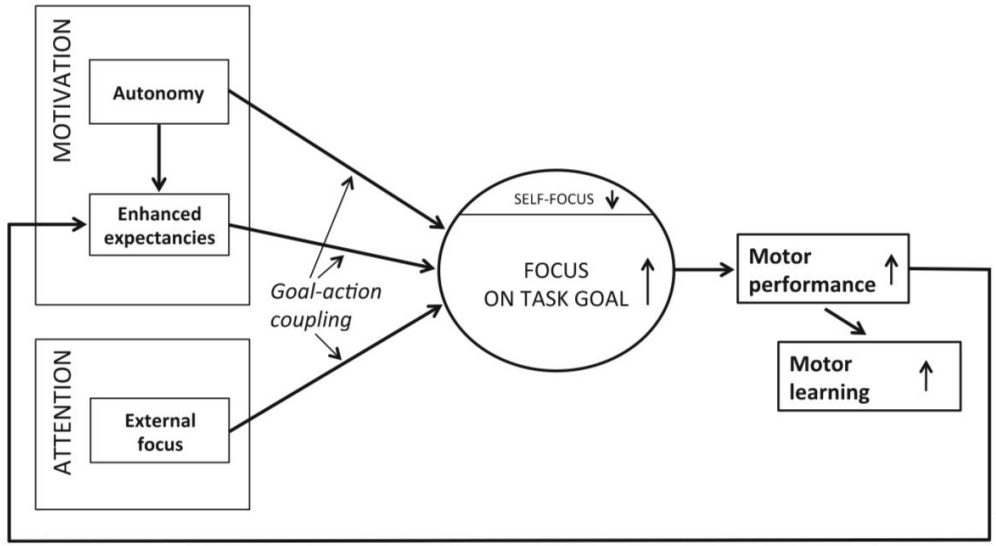
- Secondary ACL injury rates of either the same or contralateral leg are reported as high as 33%.[1]
  - This percentage is believed to be caused by returning to sport too quickly[1] as well as poor quadriceps re-education and neuromuscular control.[2]
- There is an estimate of 43% of patients that suffered an ACL injury that were also diagnosed with early-onset osteoarthritis (OA) within 10 years.[3]
- Deficient quadriceps function is associated with post-traumatic early-onset OA.[3]
- Poor functional performance at one year following ACL-R can be associated with risk of OA.[4]

# Introduction - The Solution

- One of the barriers of RTP following ACL-R is quadricep function deficits in quadriceps torque production.[5]
  - This leads to decreased somatosensory processing[6] and efferent motor drive impairments.[7]
- Current rehabilitation has been lacking in the realm of motor learning principles and strategies that could potentially improve both physical and psychological outcomes in ACL-R patients.[8]
- Motivation is a broad term that describes behavior in components of energy, direction, and intensity.[9]
  - Is a component of motor learning for its environmental impact on motor behavior.[9]
  - Feedback is thought to play a large role in motor learning and motivational increases because it allows the learner to see their performances during a certain task.[9,10]

# Introduction

- OPTIMAL Theory[9]
  - Optimizing Performance Through Intrinsic Motivation and Attention for Learning
  - Motivation component consists of autonomy support and enhanced expectancies.[9]
    - Motivation can predict sport injury and rehabilitation outcomes.[11]
    - Patient autonomy allows for greater motivation and patient engagement during motor tasks.[9,11,12,13]
  - Attentional component looks at the impact of external foci.[9]
    - External foci can be used to increase or enhance performance as well as the learning of motor skills.[12,14]




Wulf G, Lewthwaite R, 2016

# Purpose & Hypothesis

- Compared with a standard of care assessment, incorporating motor learning strategies will improve intrinsic motivation and peak quadriceps torque output in a young, healthy, asymptomatic population.

# Study Design

We employed a within-subject to treatment crossover design.

- ie. Participant #1 completes Control, Experimental so Participant #2 completes Experimental, Control
- Participants only used their dominant leg which was defined as their kicking leg.
- Independent variables
  - Control (Non-Optimized)
  - Experimental (Optimized)
- Dependent variables
  - Interest/enjoyment
  - Peak torque

# Participants

- Demographics:
  - N = 33
  - Age: 23.45±3.62 years
  - Height: 172.12±8.31 cm
  - Mass: 77.80±12.71 kg
  - 24 females, 9 males

- Inclusion criteria:
  - At least 18 years old

- Exclusion criteria:
  - History of ACL-R within 2 years
  - Over 35 years old

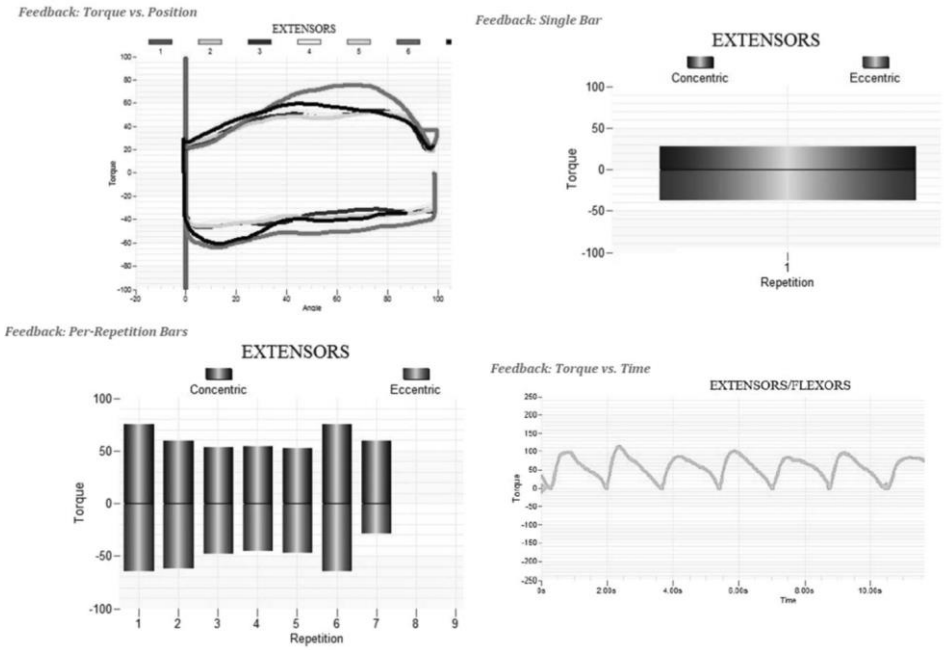
IRB #23-117

# Methods - Dynamometer

- 2 counterbalanced conditions:
  - Non-Optimized (control)
  - Optimized (experimental)
- Tested dominant kicking leg
- Kick out (isometric quadricep extension) at 45° knee flexion, 3x5 seconds with a 30 second rest period between each rep
  - Completed twice: one with the Optimized condition and one with the Non-Optimized condition

# Methods - Motivation & Attention

- Control - Non-Optimized
  - No motor learning manipulation
  - Participant was not able to see the screen
  - “Kick your leg as hard as you can”




Hogg JA et al, 2024

- Experimental - Optimized
  - Allowed selection of bar or line graph
  - “Watching the screen during your reps has been shown to increase your quadriceps force production”

# Methods - Motivation & Attention - IMI

- Intrinsic Motivation Inventory (IMI)
  - 7-item Interest/Enjoyment Subscale was used
  - Participant was asked to complete the survey after each condition rating the truth of each statement.
    - 1- not at all true
    - 7- very true

**Interest/Enjoyment**

I enjoyed doing this activity very much
This activity was fun to do.
I thought this was a boring activity. (R)
This activity did not hold my attention at all. (R)
I would describe this activity as very interesting.
I thought this activity was quite enjoyable.
While I was doing this activity, I was thinking about how much I enjoyed it.

McAuley E et al, 1989

# Data Handling

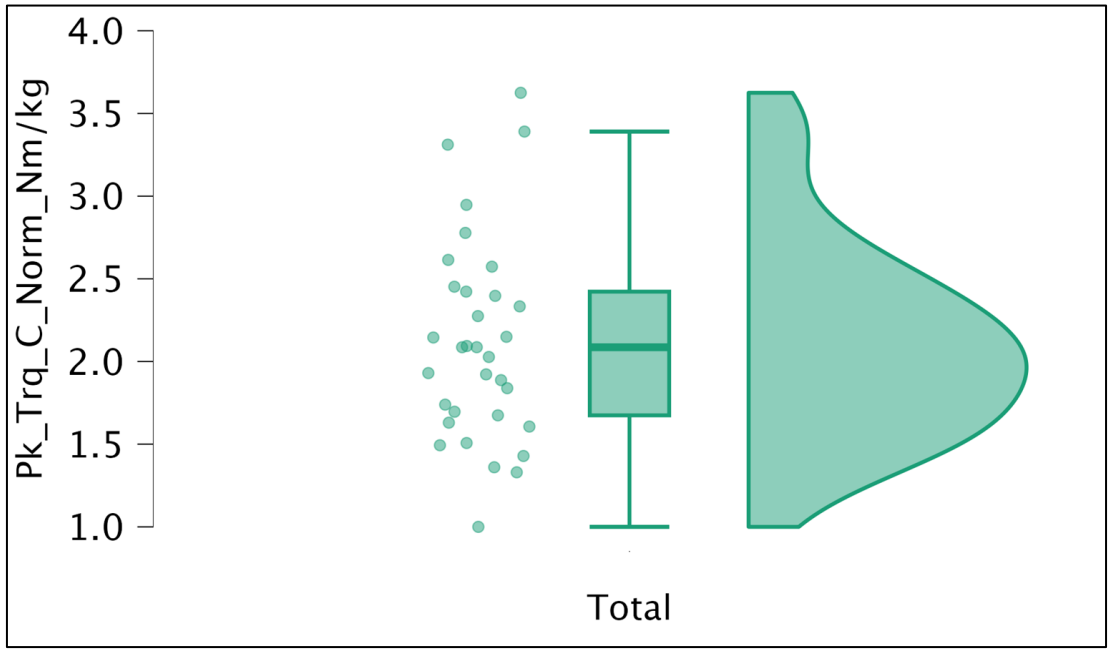
- Primary Outcome Variables
  - Peak quad torque normalized to body mass (Nm/kg)
    - Absolute peak torque as computed by the Biodex
  - Intrinsic Motivation
    - Interest/enjoyment subscale of intrinsic motivation inventory survey
    - Higher score meant higher interest/enjoyment

# Statistical Analysis

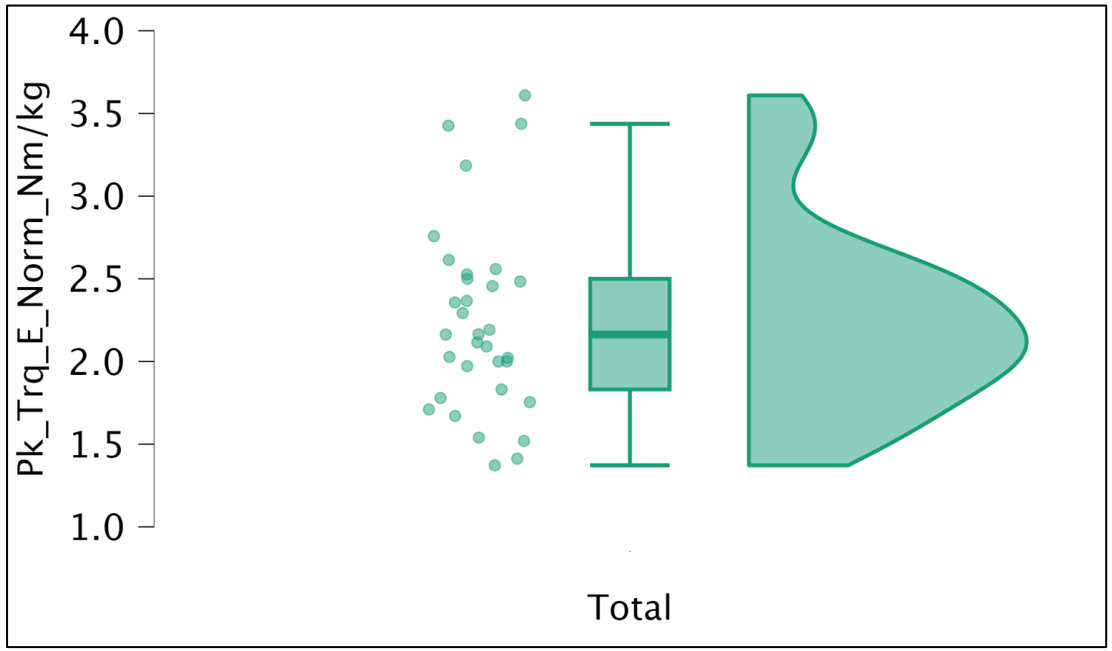
- Data were inspected for normality via histograms and outliers were removed.
- Paired samples t-tests were conducted for peak quadriceps torque and intrinsic motivation. The differences were correlated and graphed.
- A linear multiple regression was conducted to determine the extent to which increases in motivation explained variance in Optimized peak torque.
- A path model was conducted to determine potential mediation effects of intrinsic motivation on changes in peak quadriceps torque.
- JASP 0.19.3 was used for all analyses

# Results–Normality

- Missing data
  - Two subjects were lacking motivation data and one subject missed a rep for Non-Optimized torque data, which was computed manually.



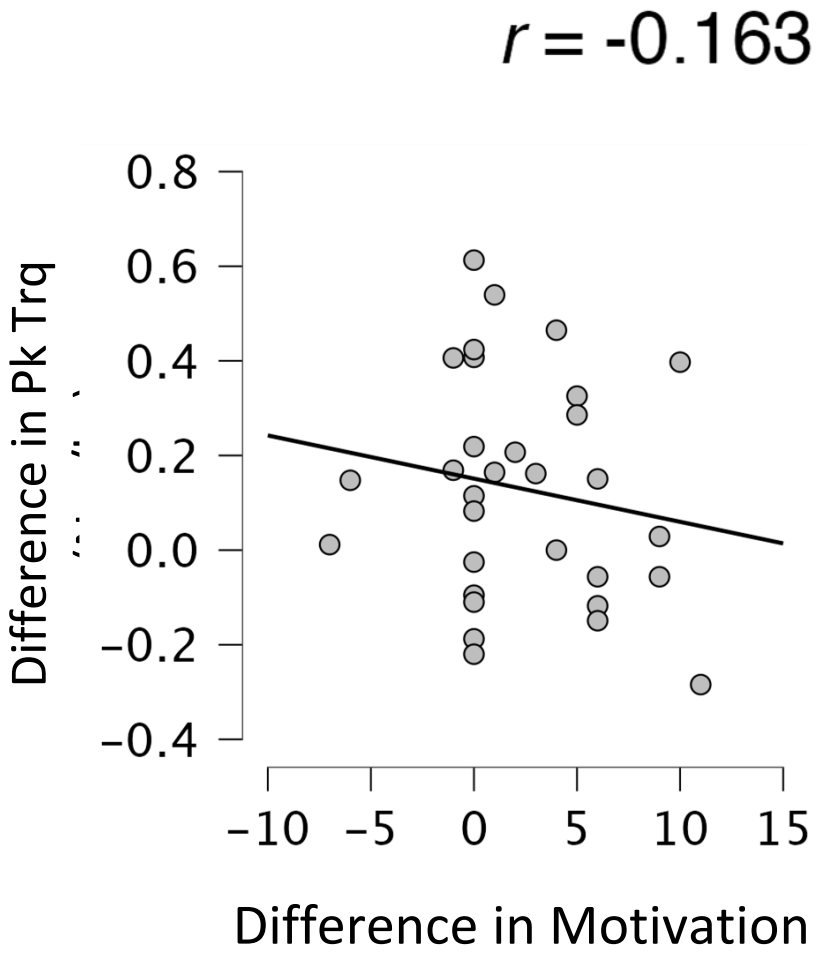

Control Peak Torque




Experimental Peak Torque

# Results–Increases in Torque and Motivation

- Peak torque increased between Non-Optimized and Optimized conditions ( $p < .01$, Cohen's $d = 0.57$)
- Motivation increased between Non-Optimized and Optimized conditions ($p = .01$, Cohen's $d = .53$)
- Differences in motivation and peak torque were minimally negatively correlated ($r = -0.16$)



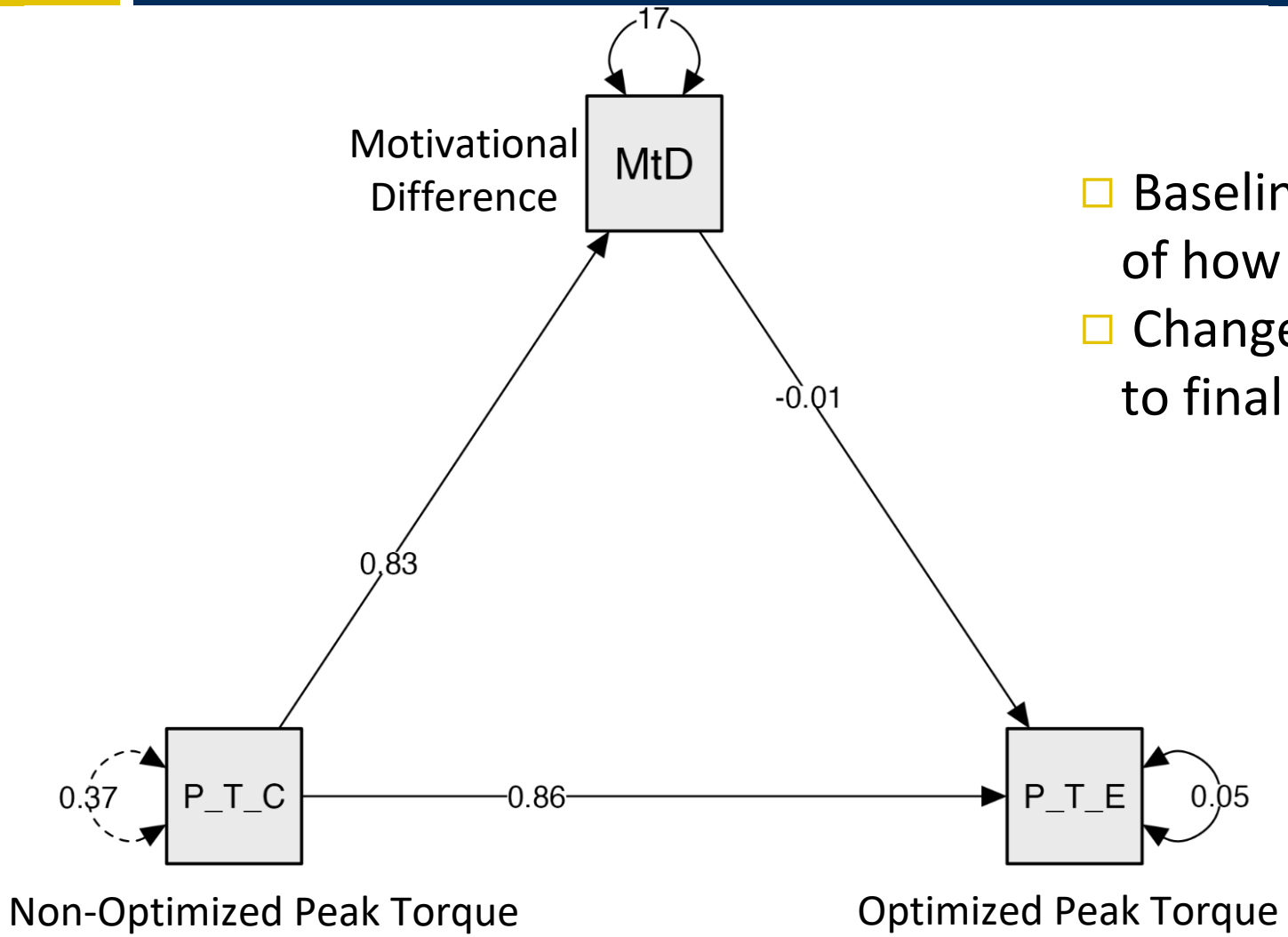
# Results–Linear Regression

- Baseline Conditions
  - Non-Optimized peak torque predicted 87% of the variance in Optimized peak torque ($p < .001$).
  - Non-Optimized interest/enjoyment explained an additional 0.8% ($R^2$ change $p$=.32)
- Addition of Motivation
  - The addition of Optimized interest/enjoyment an additional 2.4% ($R^2$ change $p$=.07)

*Model Summary – Pk_Trq_E_Norm_Nm/kg*

| Model | R | $R^2$ | Adjusted $R^2$ | RMSE | $R^2$ Change | df1 | df2 | p |
|---|---|---|---|---|---|---|---|---|
| $M_0$ | 0.000 | 0.000 | 0.000 | 0.601 | 0.000 | 0 | 18 | |
| $M_1$ | 0.933 | 0.871 | 0.864 | 0.222 | 0.871 | 1 | 17 | < .001 |
| $M_2$ | 0.938 | 0.879 | 0.864 | 0.222 | 0.008 | 1 | 16 | 0.323 |
| $M_3$ | 0.950 | 0.903 | 0.884 | 0.205 | 0.024 | 1 | 15 | 0.073 |

# Results–Potential Mediation




- Baseline peak torque was a strong indicator of how much motivation would change.
- Changes in motivation did not transfer over to final experimental peak torque.

# Discussion

- We observed moderate effects of the intervention for both the IMI-survey (Cohen's *d* of 0.53) and peak torque (Cohen's *d* of 0.57).

- **Increases** in motivation minimally correlates with **decreases** in peak torque (r = -0.16).

- Non-Optimized peak torque strongly correlates with increases in motivation, but increases in motivation do not translate to greater Optimized peak torque.

# Discussion

- The manipulation worked but the mechanism is still unknown
  - Could be the ordering of the manipulation (crossover study design or washout)
  - Could be a missing variable that we are not considering:
    - Floor effects (the stronger someone is at baseline, the more likely someone is to increase their motivation (r = .12))
    - Using different surveys to look at individual learning strategies or other trait characteristics
      - Determination
      - Grit
      - Kinesthetic learning
      - Visual learning
      - Auditory learning

# Limitations & Constraints

- Limitations
  - Kicking early
  - Fatigue during second round
  - Effort

- Constraints
  - Learning effect
    - Use of a longer washout period
    - Mixed effect model (fixed and random)

# Clinical Relevance

- Improved quadricep function
  - Greater likelihood of RTS[4]
- Optimization of patient autonomy
  - Increased patient self-efficacy[9]
- Mitigate risk of injury/re-injury[4]
  - Improved biomechanics[12]
- Patient-centered care approach
  - Inclusion of motivation based rehabilitation[9,12]


Diekfuss JA et al, 2020

# Future directions

- Using different surveys to look at individual learning styles in order to determine the mechanism
- Multisession study to determine retention effects
- Transfer of quadricep function to other tasks (e.g., jumping)
- Confirm if these results hold in a pathological population

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