

Rethinking Rehabilitation to Improve Outcomes after Lower Extremity Trauma

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Disclosures:

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Data collected part of PhD dissertation of Josh Van Wyngaarden DPT


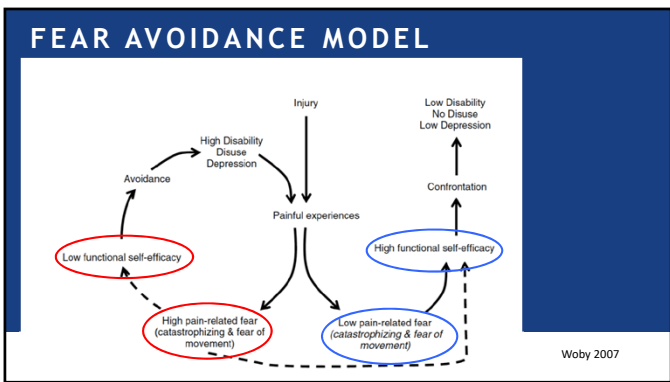
On loan from Air Force

All work today is unpublished from his work





OUTLINE


- 1) Examine three domains for poor outcomes after a lower extremity trauma
 - A) Psychosocial: Maladaptive beliefs and expectations that may influence recovery from injury
 - B) Physical: Share our early pilot data on the state of recovery at a 1 year follow up
 - C) Pain: Factors resulting acute to chronic pain transition
- 2) Intersection between each of these domains
- 3) How this leads to new avenues for treatments and challenges current practice

POOR PHYSICAL RECOVERY PERSISTS AFTER TRAUMA




- Estimated over 500,000 long bone fractures per year (Gross et al., 2016)
- 47% report physical disability at 12 months (Trickett et al., 2012)
 - Results in economic hardship (Tay et al., 2014)
- Little is still known on recovery of muscle function
- Strength impairments 1-3 years post injury (Bain et al., 1997; Sluys et al., 2016)
- Considering muscle bone interactions, a weak muscle on recovering bone= long term problems?




PAIN PREVALENCE POST TRAUMA

- Nearly 50% of patients will develop chronic pain (Clay 2012)
- 62.7% report chronic pain 12-months after major trauma (Rivara 2008)
- 39% Grade II or higher on Chronic Pain Grade Scale 84 months after severe LE trauma (Castillo 2006)



PURPOSE: KENTUCKY LE TRAUMA STUDY

- 1) Determine the earliest time point psychosocial factors can be screened for after injury.
- 2) Evaluate how patients perform with functional testing 12-months after lower extremity fracture.
- 3) Assess how psychosocial factors are associated with the transition to chronic pain and physical performance testing.



RECRUITMENT


University of Kentucky Department of Orthopaedic Surgery 12-2017 to 02-2019 (15 months)

Inclusion Criteria:

- Age 18-70 years
- Acute orthopedic injury to the pelvis, acetabulum, or lower extremity requiring surgical fixation
- GCS=15 on admission
- Able to read and speak English

Exclusion Criteria:

- Past history of chronic pain
- Moderate or severe TBI
- Initial treatment requiring amputation
- Prior neurologic disorder
- Alcohol/Drug addiction
- Self-inflicted injury
- Severe problems with maintaining follow-up anticipated



RECRUITMENT


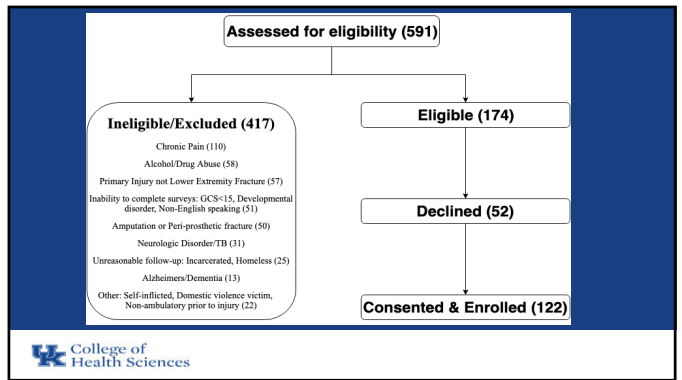
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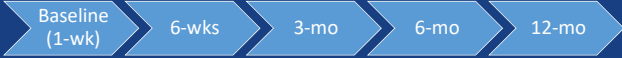

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METHODS

- Study Design: Prospective Longitudinal Cohort Study
- Consenting subjects complete surveys after definitive fixation:


METHODS: DATA COLLECTED

Psychosocial Measures

- Pain Catastrophizing Scale
 - 13 items
- Pain Self-Efficacy Questionnaire
 - 10 items
- Brief Pain Inventory-Pain Severity
 - 4 items
- Tampa Scale of Kinesiophobia
 - 17 items
- PROMIS Depression
 - Computer Adaptive Test (CAT) module: 4-10 items

Outcome Measures (12-mo)

- Chronic Pain
- Physical Performance Testing
 - Isometric Quadriceps Strength
 - SL Calf Raise
 - SL Step down
 - 6-min walk
 - Loading during Gait



12-MO PERFORMANCE TESTING



Quadriceps and Gastroc Strength



Loading during a 6 minute walk test




Functional testing


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LOADING DATA FROM SINGLE SENSOR


a) Data Collection



b) Step Feature Extraction

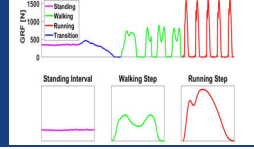


c) Activity Classification (9-fold cross validated)



d) Evaluation Metric & Univariate Results

Classification Accuracy (%)	Correct	Total
Stance Time	303	303
Insole	293	293
Load	292	292
Kinetics & Streness	292	292
Walking Rate	292	292
Running Rate	292	292
Mean Value	292	292
Classification Accuracy (%)	54.5	54.5

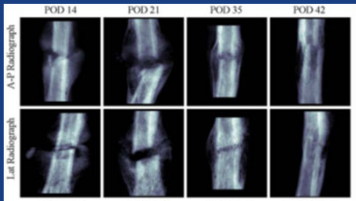


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Spencer A, 2019: Unpublished dissertation data

mRUST scoring

- Used modified RUST scoring in 60 subjects at 12 weeks
- Range 4-16 (cooke et al., 2018)
- Sum of scores from 4 cortices
 - AP and Lat radiograph
 - 1= no callus
 - 2= callus present
 - 3= bridging callus
 - 4= remodeled and fracture line not present
- ICC= 0.71 (cooke et al., 2018)
- BMD: r= 0.85
- Callus strength r= 0.35
- Callus rigidity r= 0.50



mRUST=8 mRUST=9 mRUST=13 mRUST=14

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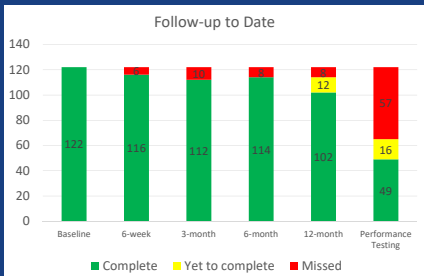
Cooke et al., 2018

STATISTICAL ANALYSIS

- Determine the earliest time point psychosocial factors can be screened for after injury.
 - One-way Analysis of Variance (ANOVA)
 - 2x5 Repeated measures ANOVA
- Evaluate how patients perform with functional testing 12-months after lower extremity fracture.
 - Paired t-tests
- Assess how psychosocial factors are associated with the transition to chronic pain and physical performance testing.
 - Multiple Logistic and Linear Regression Analyses

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Follow-up to Date



Time Point	Complete	Yet to complete	Missed
Baseline	123	0	0
6-week	116	0	0
3-month	111	0	0
6-month	114	0	0
12-month	102	12	0
Performance Testing	49	16	57

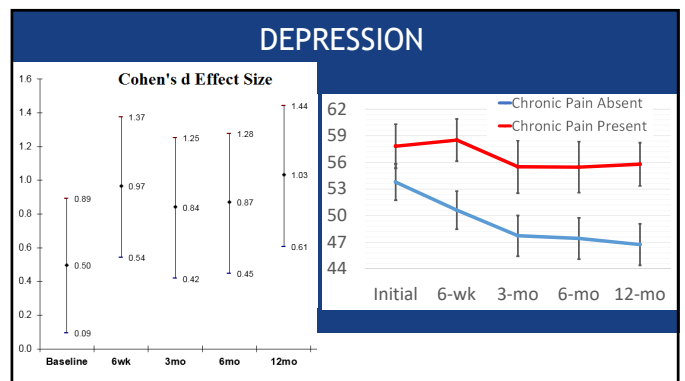
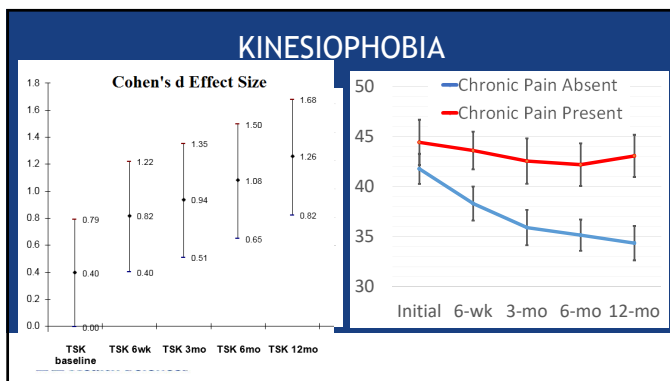
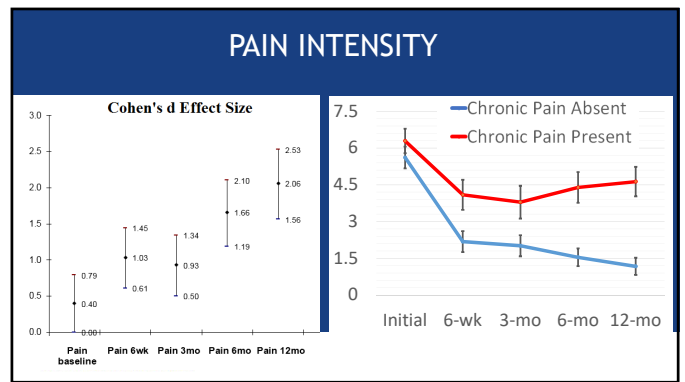
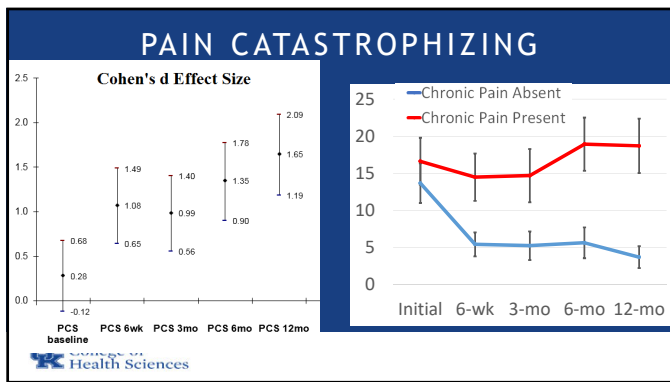
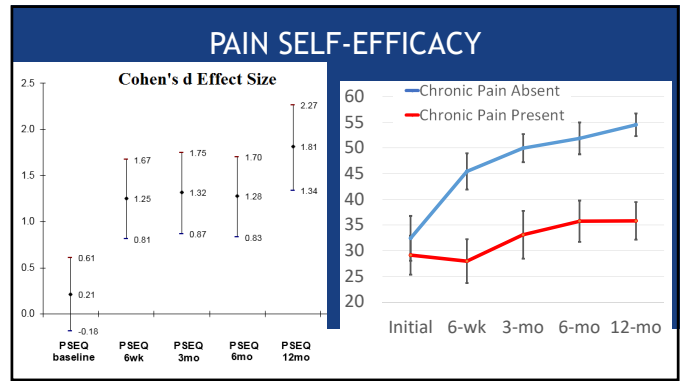
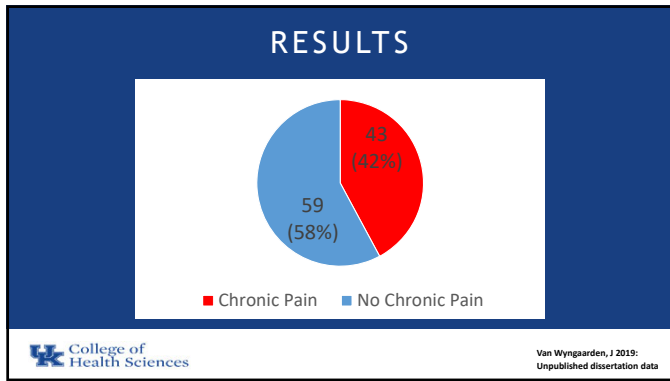
Follow-up rate: 92-93%

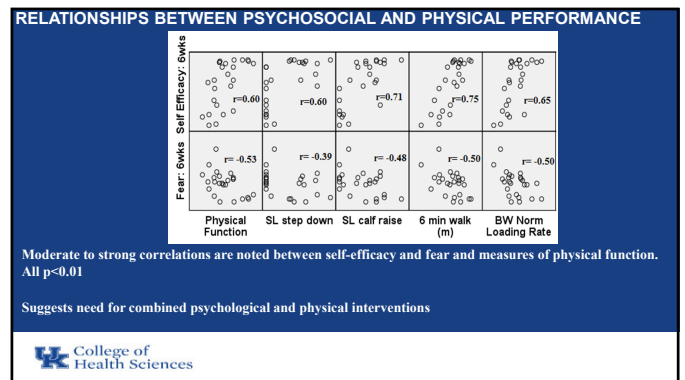
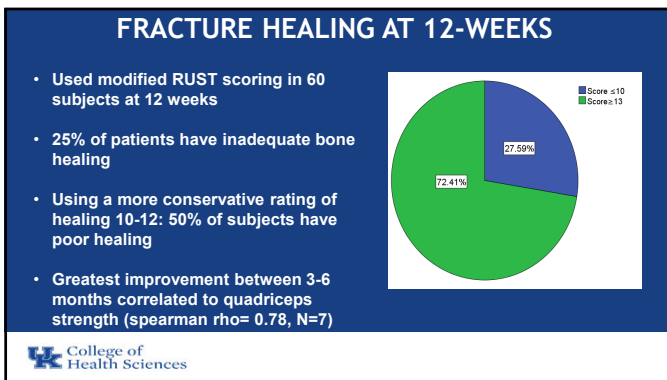
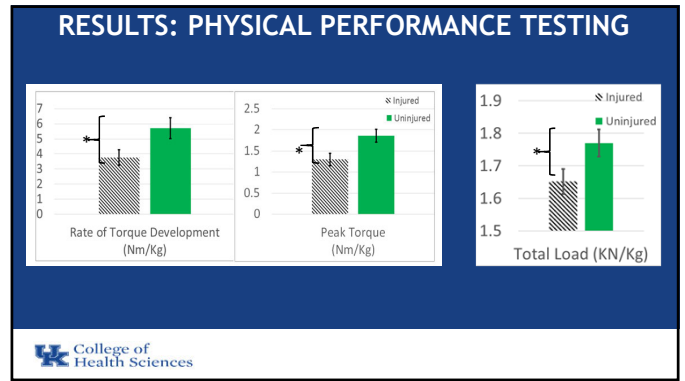
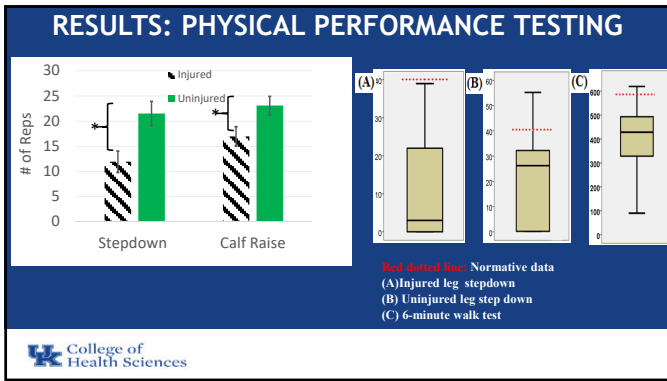
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DESCRIPTIVE STATISTICS

Age	41.7 ± 14.7	Primary Injury Location	
Body Mass Index (BMI)	31.2 ± 9.4	Pelvis/Acetabulum	21 (17)
Gender		Femur	30 (25)
Female	56 (46)	Tibia	63 (51)
Male	66 (54)	Patella	2 (2)
Race		Ankle/Foot	6 (5)
White	110 (90)	Articular injury	
Nonwhite	12 (10)	Yes	55 (45)
Education		No	67 (55)
High School or less	49 (41)	Injury Severity Score	9.1 ± 6.6
Greater than High School	72 (59)	Length of Hospital Stay	3.5 ± 3.4
Current Smoker	33 (27)		
Mechanism of injury			
Motor Vehicle Accident	46 (38)		
Motorcycle Accident	13 (11)		
Pedestrian/cyclist hit by vehicle	9 (7)		
Fall	36 (29)		
Blunt Trauma	13 (11)		
Other	5 (4)		

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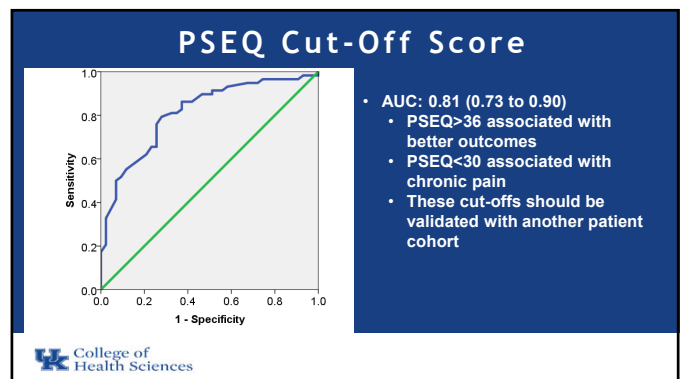




RESULTS: CHRONIC PAIN

IVs at 6-weeks	p-value	Exp(B)	Exp(B) 95% CI
Education Level	0.11	0.38	0.11-1.24
Injury Severity Score	0.93	1.01	0.91-1.09
Pain Severity	0.12	1.18	0.92-2.05
Articular Injury	0.02	3.87	1.23-12.2
Depression	0.051	1.08	1.0-1.18
Pain Catastrophizing	0.68	1.03	0.94-1.14
Pain Self-Efficacy	0.01	0.94	0.90-0.98
Fear of Movement	0.68	0.98	0.87-1.10

Nagelkerke R²=0.54 p-value <0.001



RESULTS: INJURED SL STEP DOWNS

	β -coefficient	P-value
Age	-0.41	0.002
BMI	-0.156	0.45
Education	-0.22	0.95
Pain Self-efficacy	0.27	0.015

N=39
long bone fractures
ADJ R²=0.41

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RESULTS: INJURED SL CALF RAISES

	β -coefficient	P-value
Age	-0.113	0.27
BMI	-0.49	0.006
Education	2.95	0.34
Pain Self-efficacy	0.291	0.002

N=39
long bone fractures
ADJ R²=0.51

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RESULTS: 6-MIN WALK TEST

	β -coefficient	P-value
Age	-2.56	0.02
BMI	-4.18	0.03
Education	40.26	0.22
Pain Self-efficacy	2.71	0.009

N=38
long bone fractures
ADJ R²=0.51

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RESULTS: MAX QUAD STRENGTH

	β -coefficient	P-value
Age	-0.027	<0.001
Education	0.165	0.45
Pain Self-efficacy	0.014	0.02

N=39
long bone fractures
ADJ R²=0.39

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MULTIDIMENSIONAL SCREENING

- While self-efficacy is important, we know multiple psychosocial factors interact to predict patient outcomes
 - Need for a multidimensional assessment tool
- STarT Back Screening Tool is effective at predicting 6-mo disability in LBP population
 - 4 Physical Function Questions
 - 5 Psychosocial Question
 - Fear of movement
 - Pain Catastrophizing
 - Anxiety
 - Depression
 - Bothersomeness
 - Stratifies individuals into Low, Medium, and High Risk Groups
 - Easily Modified to test efficacy in patients with lower extremity trauma (STarT-LE)

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STarT-LE RELIABILITY & CONTENT VALIDITY

ICC (3,1)

	Test-Retest Reliability
mSBT Total Score	0.85 (95% CI: 0.78-0.91)
Psychosocial Subscale	0.79 (95% CI: 0.68-0.87)

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STarT-LE: CONSTRUCT VALIDITY

Moderate to strong construct validity. All p-values < 0.001.

	PCS	PSEQ	BPI	TSK	Depression	Pain Interference
mSBT Total	0.75	-0.68	0.59	0.59	0.55	0.67
Psychosocial Subscale	0.68	-0.66	0.48	0.60	0.53	0.61

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STarT-LE: CONSTRUCT VALIDITY

mSBT Risk Category	PCS	PSEQ	TSK	BPI	Depression	Pain Interference
Low Risk (N=35) mean ± SD 95% CI	2.5 ± 3.5 1.3-3.7	52.1 ± 8.2 49.3-54.9	35.3 ± 5.3 33.5-37.2	1.6 ± 1.3 1.1-2.0	47.0 ± 8.9 44.0-50.1	52.8 ± 5.8 50.8-54.8
Moderate (N=61) mean ± SD 95% CI	9.3 ± 7.1 7.5-11.1	35.0 ± 14.3 31.4-38.7	41.7 ± 4.9 40.4-43.0	3.3 ± 1.9 2.8-3.8	56.2 ± 6.9 54.4-58.0	60.4 ± 7.1 58.6-62.2
High (N=20) mean ± SD 95% CI	22.2 ± 11.8 16.7-27.7	23.4 ± 11.8 17.9-28.9	46.7 ± 7.2 43.3-50.1	4.9 ± 1.9 4.0-5.8	60.5 ± 7.4 57.1-64.0	66.0 ± 3.7 64.3-67.8

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DISCUSSION

- PSEQ is the strongest psychosocial predictors of chronic pain
 - Each 10 point increase in PSEQ is associated with a 60% decrease in odds of developing chronic pain
 - Screening for self-efficacy may help ID those who need targeted intervention to improve patient confidence
 - Psychological intervention and/or graded exercise progression
- Long-term predictive effect of the STarT-LE unknown
 - Cross-sectional study demonstrates it represents multiple psychosocial factors simultaneously
 - Is the STarT-LE better at stratifying risk than PSEQ?
 - Or can they work together?

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DISCUSSION

- Significant functional limitations persist 12-months after surgery
 - Only 1 published study on post operative rehabilitation (Paterno, 2009)
 - Lack of rigorous studies on optimal rehabilitation
 - Our pilot work suggests:
 - Need for intensive progressive resistance strengthening exercises
 - Promotion of weight-bearing activity, potentially more single leg activity
 - Greater attention on muscle endurance and control exercises
 - PSEQ at 6-weeks is moderately associated with each outcome
 - Combined psychosocial/physical rehabilitation
 - Identify cohorts that need such a specialized treatment early

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LIMITATIONS

- Could there be an earlier time point 3-6 weeks were divergence starts
- The effect of pain medication use on our results is unknown
- Excluded people with prior chronic pain, unclear if they respond differently
- Were not able to track what they did for rehabilitation closely
- Single-Center Design
- Broad range of injuries, age and BMI, limits ability to study subgroups or specific injuries

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FUTURE DIRECTIONS

- Added a number of Quantitative Sensory Testing measures:
 - Repeated at 6-wks, 3-mo, 6-mo, and 12-mo
 - Pain Pressure threshold
 - Temporal summation
 - Conditioned Pain Modulation
 - Heat Tolerance
 - Cold and Vibratory Perception Threshold
- Tracking pain and return to work outcomes to 2 years
- Fracture healing appears to be delayed in many long bone fractures
 - Muscle recovery is not optimal, looking to extend this work to the interaction with bone and fracture healing

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Collaborators:
Orthopaedics and Sports Medicine:
 Darren Johnson MD
 Paul Matuszewski MD
 Arun Aneja MD
 Mary Lloyd Ireland MD
 Cale Jacobs ATC, Ph.D.
Exercise Sciences:
 Mike Samaan Ph.D.
Computer Science:
 Ruigang Yang Ph.D.
Statistics:
 Katie Thompson Ph.D.
Radiology and MRISC:
 Peter Hardy Ph.D.
 Anders Anderson Ph.D.
CCTS:
 Phil Kern MD
College of Health Sciences:
 Charlotte Peterson Ph.D.
 Chris Fry Ph.D.

Biomotion Lab
 5 Ph.D. Students
 8 Undergraduate research scholars



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 METRC Young Investigator Grant (Matuszewski PI)



National Institutes of Health
 Grants
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 AR072061

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BACKGROUND: PSYCHOSOCIAL SCREENING

- Psychosocial factors are important prognostic factors (Boissonneault and George 2017)
- Literature supporting the influence psychosocial factors carry has grown in patients with orthopaedic trauma (Castillo 2018, Archer 2015)
- Standard of care intervention for this population has remained unchanged
 - Minimal research has attempted to stratify care based on the presence of modifiable factors after trauma
- Validating a simple, multidimensional tool to screen for risk is indicated

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BACKGROUND: STarT BACK SCREENING TOOL

- Subgroups for Targeted Treatment Back Screening Tool (STarT) validated (Hill 2008)
- Individuals categorized as low, moderate or high risk
- Demonstrates strong psychometric properties and predictive validity for 6-month disability (Hill 2008)
- RCT found that intervention by risk category significantly improved:
 - Disability at 4 and 12 months
 - Health related quality of life
 - Cost of care (Hill 2011)

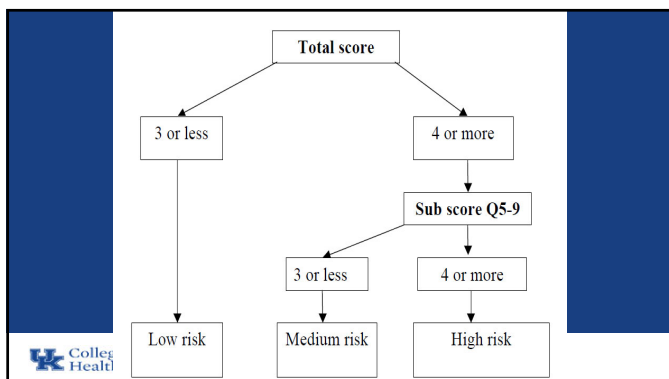
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mSBT Total score

Psychosocial Sub-score

- I have had at least one of the following in my leg at some point in the last 2 weeks: **numbness, tingling, electric sensations, or burning sensations**
- I have had pain **spread from the original site of injury to another portion of my leg, hip, or back** at some point in the last 2 weeks
- I have only walked short distances because of my **leg pain**
- In the last 2 weeks, I have dressed more slowly than usual because of **leg pain**
- It's not really safe for a person with a condition like mine to be physically active
- Worrying thoughts have been going through my mind a lot of the time
- I feel that **my leg pain** is terrible and it's never going to get any better
- In general I have not enjoyed all the things I used to enjoy
- Overall, how bothersome has your **leg pain** been in the last 2 weeks?

Not at all	Slightly	Moderately	Very much	Extremely
0	0	0	1	1



PURPOSE: Aim 3


Determine if a modified version of the STarT Screening Tool is a valid tool to predict chronic pain, pain interference, pain intensity, and physical function in patients with LE fracture.

Specific Aim: Establish the predictive validity of the STarT-Lower Extremity at 6-weeks for chronic pain development, severe pain interference, pain intensity and worse self-reported physical function at 12-months.

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METHODS: Aim 3

- mSBT administered at 6- and 12-weeks
 - Along with PCS, PSEQ, BPI, TSK, & PROMIS Depression and Pain Interference
- Retest at 7 week
 - Global Rating of Change Score \pm 2
- Outcome measures evaluated at 12-months:
 - Chronic Pain
 - PROMIS Pain Interference
 - PROMIS Physical Function
 - Pain Severity



STATISTICS: Aim 3

- Predictive Validity
 - Sensitivity/Specificity
 - +/- Likelihood Ratios
 - Linear Regression Controlling for Baseline Variables



RESULTS: PREDICTIVE VALIDITY

Outcome	Case Definition	Subgroup Cutoff	Sensitivity %	Specificity %	Neg. LR (95% CI)	Pos. LR (95%CI)
Chronic Pain	Yes	L v M/H H v M/L	90.7 34.9	50.0 96.4	0.19 (0.07-0.49) 0.66 (0.54 to 0.85)	1.81 (1.37 to 2.40) 9.77 (2.36 to 40.45)
Pain Interference	1SD above mean	L v M/H H v M/L	94.4 27.78	47.6 88.89	0.12 (0.03 to 0.46) 0.81 (0.65 to 1.01)	1.8 (1.41 to 2.31) 2.50 (1.04 to 6.00)
Physical Function	1SD above mean	L v M/H H v M/L	85.7 31.43	42.2 90.62	0.34 (0.14 to 0.8) 0.76 (0.60 to 0.96)	1.48 (1.16 to 1.9) 3.35 (1.36 to 8.29)
Pain Severity	Pain \geq 5.0	L v M/H H v M/L	95.0 40.0	39.2 88.61	0.13 (0.02 to 0.88) 0.68 (0.47 to 0.98)	1.56 (1.28 to 1.92) 3.51 (1.55 to 7.94)


RESULTS: PREDICTIVE VALIDITY

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RESULTS: Chronic Pain

	p-value	Exp(B)	Exp(B) 95% CI
BMI	0.34	1.03	0.97-1.10
Injury Severity Score	0.87	1.01	0.92-1.10
Age	0.57	0.99	0.95-1.03
Education	0.13	0.41	0.13-1.31
Smoking Status	0.01	5.88	1.49-23.17
STarT-LE Risk Category	<0.001	11.23	3.30-38.30


Nagelkerke R²=0.51 p-value <0.001



RESULTS: Pain Severity

	β -coefficient	P-value
BMI	0.03	0.16
Injury Severity Score	0.02	0.51
Age	-0.009	0.53
Education	0.31	0.45
Smoking Status	0.63	0.19
STarT-LE Risk Category	0.61	0.08
Pain Severity	0.61	<0.001

ADJ R²=0.46



RESULTS: Pain Interference

	β -coefficient	P-value
BMI	0.15	0.15
Injury Severity Score	0.06	0.65
Age	0.02	0.77
Education	0.82	0.65
Smoking Status	3.14	0.14
StarT-LE Risk Category	3.22	0.06
Pain Interference	0.50	0.001

ADJ R²=0.36

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RESULTS: Physical Function

	β -coefficient	P-value
BMI	-0.20	0.03
Injury Severity Score	-0.15	0.20
Age	-0.14	0.02
Education	1.18	0.47
Smoking Status	-0.21	0.91
StarT-LE Risk Category	-4.52	0.004
Physical Function	-0.43	0.001

ADJ R²=0.47

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Discussion Items

Figure 6: The functional measures of single leg step downs and 6-minute walk testing carry moderate to strong associations with strength and self-reported function 12-months after surgical fixation (N=30).

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