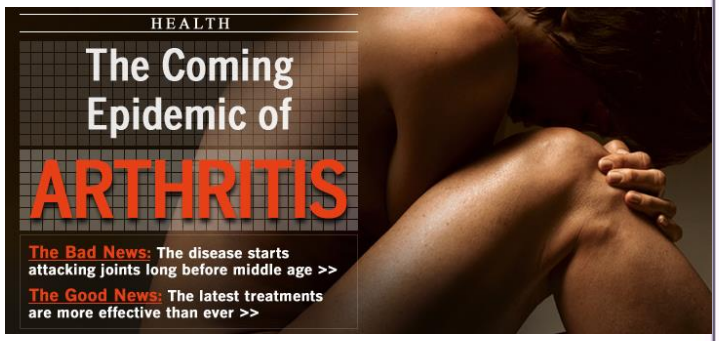
Quadriceps Functions and Mobility Performance in Individuals after Total Knee Arthroplasty

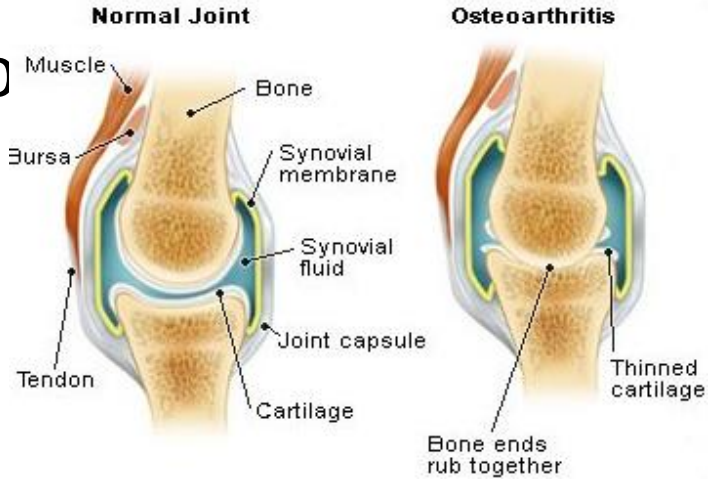
Yuri Yoshida, PT, PhD
Assistant Professor
Dept of Physical Therapy
University of Evansville

Osteoarthritis



- The most common arthritis
  - 27 million people are affected
  - 80% of the population over 65 y.o.

- Chronic inflammatory conditio
  - Damaged joint surface
  - Effusion
  - Pain
  - Instability/Stiffness
  - Muscle Weakness



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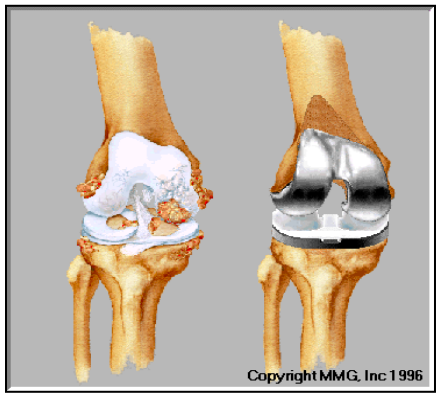
Total Knee Arthroplasty



- Most common surgery
  - 600,000 people in the US *(AAOS 2012)*
  - Patients < 60 y.o. requiring TKA have increased.
- One of the Most Successful Surgeries
  - ~80% patients are satisfied with their functional outcomes.

(Beaupre 04, Conditt 04, Noble 05)

  - >95% of prosthetics can survive over 10 to 12 years

(Rand, Trousdale et al. 2003)

  - Functional recovery????

(Mizner 05, Kennedy 06)

What is Missing?

THE JOURNAL OF BONE & JOINT SURGERY
JBJS

This is an enhanced PDF from The Journal of Bone and Joint Surgery
The PDF of the article you requested follows this cover page.

NIH Consensus Statement on Total Knee Replacement December 8-10, 2003

J Bone Joint Surg Am. 86:1328-1335, 2004.

"Despite the wide-spread use of TKR, there is a notable lack of consensus regarding which medical and rehabilitative perioperative practices should be employed, mostly because of the lack of well-designed studies testing the efficacy and effectiveness of such practices."

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BMJ

RESEARCH

Effectiveness of physiotherapy exercise after knee arthroplasty for osteoarthritis: systematic review and meta-analysis of randomised controlled trials

Catherine J Minns Lowe, research fellow,[1] Karen L Barker, director,[2] Michael Dewey, special lecturer,[3] Catherine M Sackley, professor of physiotherapy research[1]

"Effect sizes are small to moderate, with no long term benefit"

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Clinical Section

Gerontology 1998;44:204–210

Received: February 21, 1997
Accepted: April 23, 1997

Total Knee Arthroplasty in the Elderly: Patients' Self-Appraisal 6 and 12 Months Postoperatively

Ruth Dickstein
Yael Heffes
Esther I. Shabtai
Emanuel Markowitz

Flieman Geriatric Rehabilitation Hospital, Haifa, and Department of Physical Therapy, Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel

"… and to the limitations in using stairs as the variables which significantly affected the levels of dissatisfaction 1 year postoperatively."

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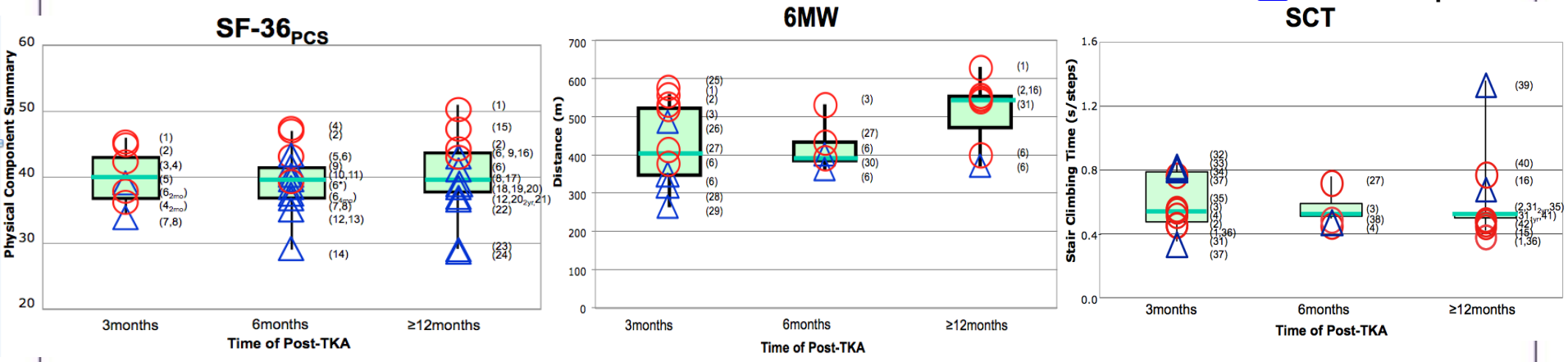
Physical Therapy Does Work!

With outpatient PT
Without outpatient PT



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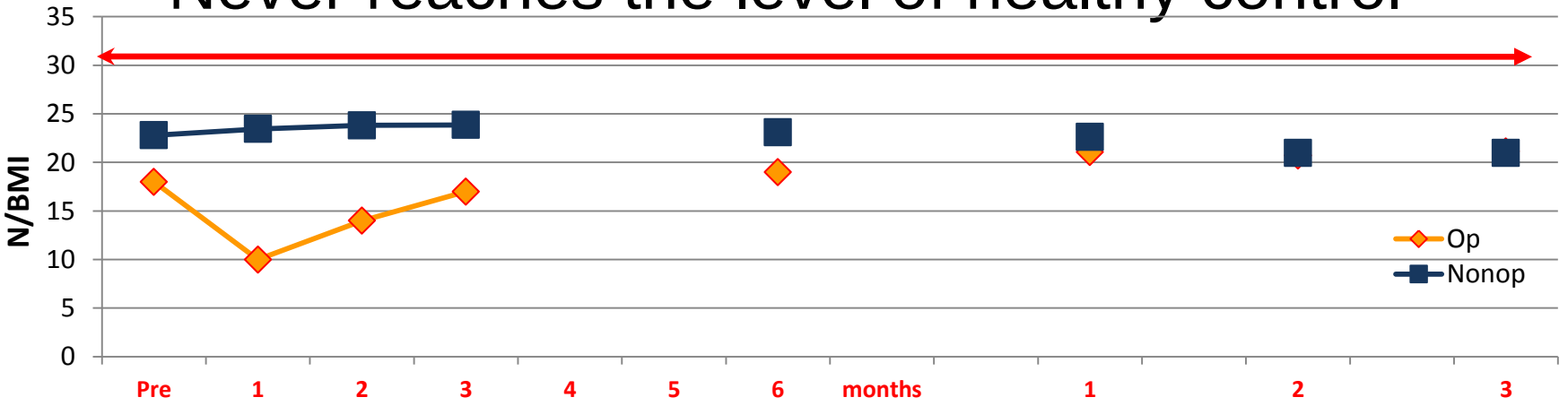
Post-TKA Impairment

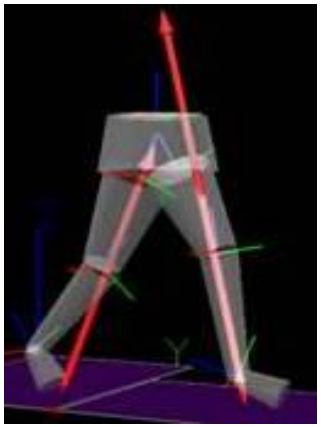
- Post-surgery inflammatory conditions
- Quadriceps weakness
  - Is the primary impairment related to mobility level over time *(Mizner 05, Petterson 08, Farquhar 09)*
  - Never reaches the level of healthy control

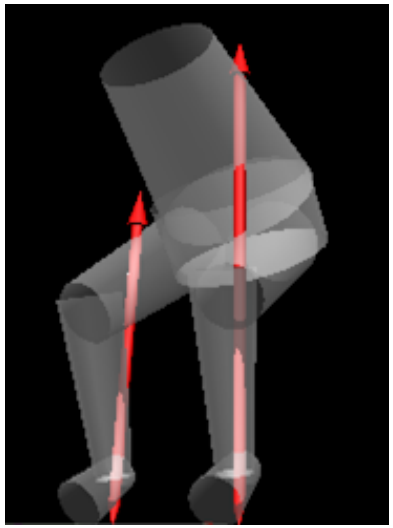


Quadriceps Strength and Functional Performance

- 3 months: Asymmetrical functional performance related to asymmetrical quadriceps strength by relying on the non-operated limb.

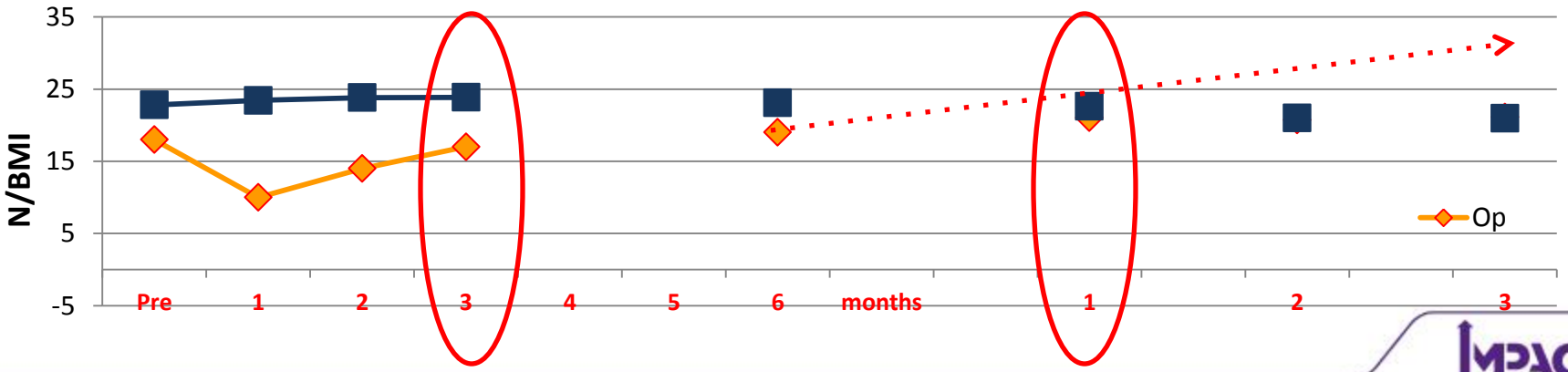
(Mizner 05)



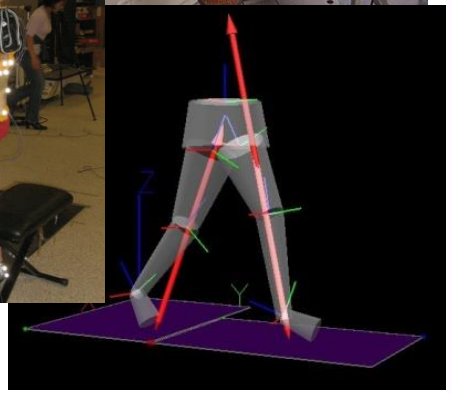


Research Questions

- How does enhanced quadriceps strength affect the altered gait performance for individuals after TKA over time ?
- Why does quadriceps weakness in the operated limb remain?



Project



- 13 subjects with UTKA
- 13 age-matched healthy controls
- Delaware OA profile
  - KOS-ADLS, SF-36
  - ROM, Knee girth
  - TUG, SCT, 6MW
  - MVIC, CAR
- Motion Analysis
  - Vicon workstation
  - 2 Bertec Force plates
  - Motion analysis EMG system
    - **Loading Response**: Knee flexion excursion, peak knee flexion, v-GRF, knee extensor moment, EMG)

Improvements in Clinical Assessments

		TKA (N=13)			Age-matched Healthy (N=13)		
		3 months		2-3 years	Baseline	Follow-up	
Height (m)		1.7 ± 0.1			1.8 ± 0.1		
Weight (kg)		90.4 ± 11.6		88.6 ± 10.7	93.0 ± 17.2	91.7 ± 15.9	
BMI (kgm2)		30.8 ± 4.0		30.3 ± 3.9	30.6 ± 5.7	29.9 ± 4.9	
SF-36 PCS		45.7 ± 7.8		46.9 ± 9.0	52.3 ± 5.7	49.9 ± 7.5	
SF-36 MCS		58.2 ± 5.1		56.5 ± 4.3	58.1 ± 1.9	56.9 ± 4.1	
KOS-ADLS		0.79 ± 0.11	§ §	0.88 ± 0.01 *	0.99 ± 0.02	0.94 ± 0.09	*
TUG (s)		7.5 ± 1.3		7.1 ± 1.1	6.8 ± 1.0	7.2 ± 1.1	
SCT (s)		11.5 ± 3.0	§	10.5 ± 2.3	9.1 ± 1.2	10.3 ± 1.3	**
6MW (m)		577.7 ± 105.9		610.6 ± 110.7	652.5 ± 129.9	629.3 ± 104.8	
e-ROM (º)	¶ ¶	1.5 ± 2.4		-1.9 ± 3.6	-0.4 ± 2.1	-2.2 ± 3.1	
f-ROM (º)		119.1 ± 8.7	§ §	126.8 ± 9.4 *	133.6 ± 8.2	131.9 ± 8.4	
MVIC (N/BMI)	(op)	18.5 ± 7.1	§ §	20.0 ± 7.2 * *	k28.8 ± 7.5	22.4 ± 8.4	**
	¶ (non-op)	27.8 ± 9.3		21.8 ± 8.5	27.8 ± 5.8	23.2 ± 7.6	
CAR (%)	(op)	93.2 ± 4.6		91.1 ± 9.6	91.5 ± 6.4	88.8 ± 8.9	
	(non-op)	92.2 ± 6.1		89.4 ± 8.6	90.0 ± 6.2	88.1 ± 11.6	

* p<0.05 A significant difference compared to the previous session within a group
** p<0.01 A significant difference compared to the previous session witnhin a group
§ p<0.05 A significant difference compared the healthy control group.
¶: p<0.05 A significant change over time in both groups.
¶¶: p<0.01 A significant change over time in both groups.

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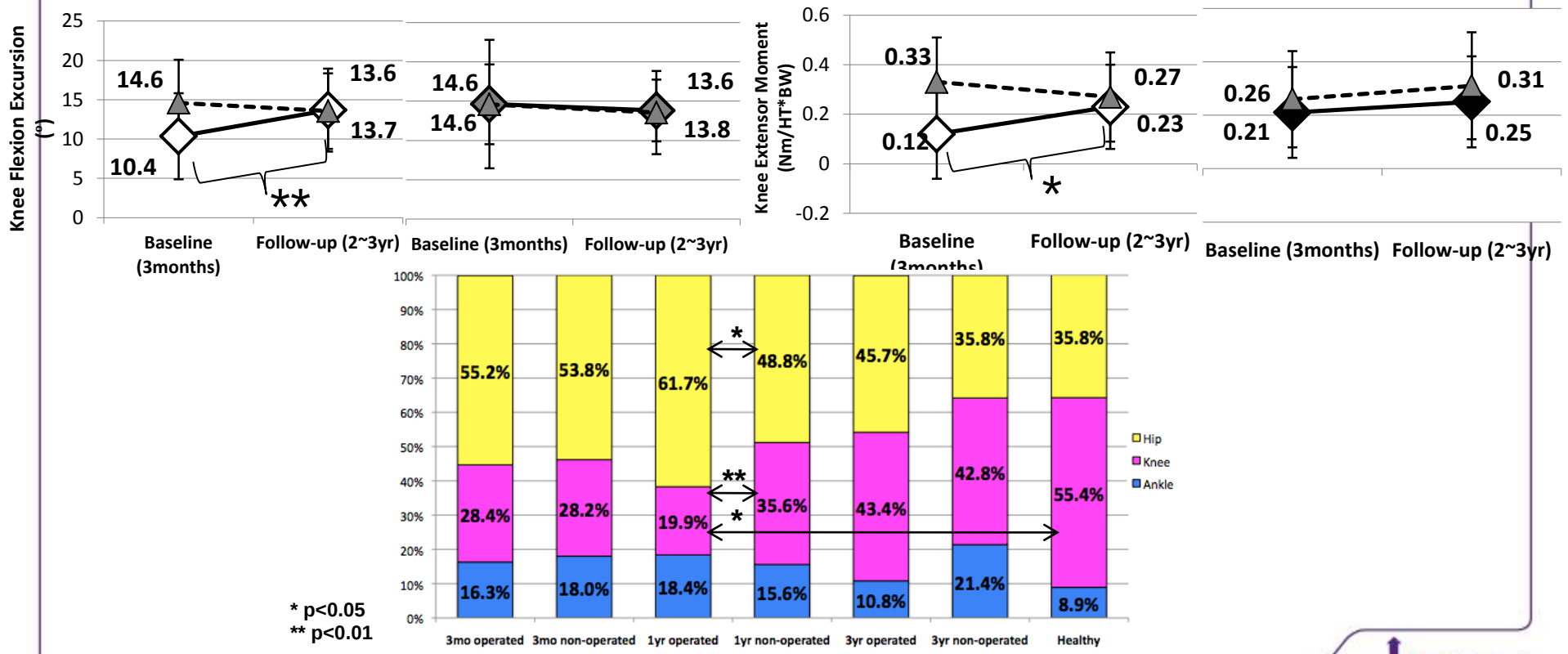
Individuals after TKA can achieve symmetrical gait patterns but, it is significantly different from healthy controls.

(Clinical Biomech 07, JOSPT 12



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The Best Case Scenario!

- Typically, individuals after TKA
  - Walk slower, and abnormal gait patterns (e.g. lower knee extensor moment).

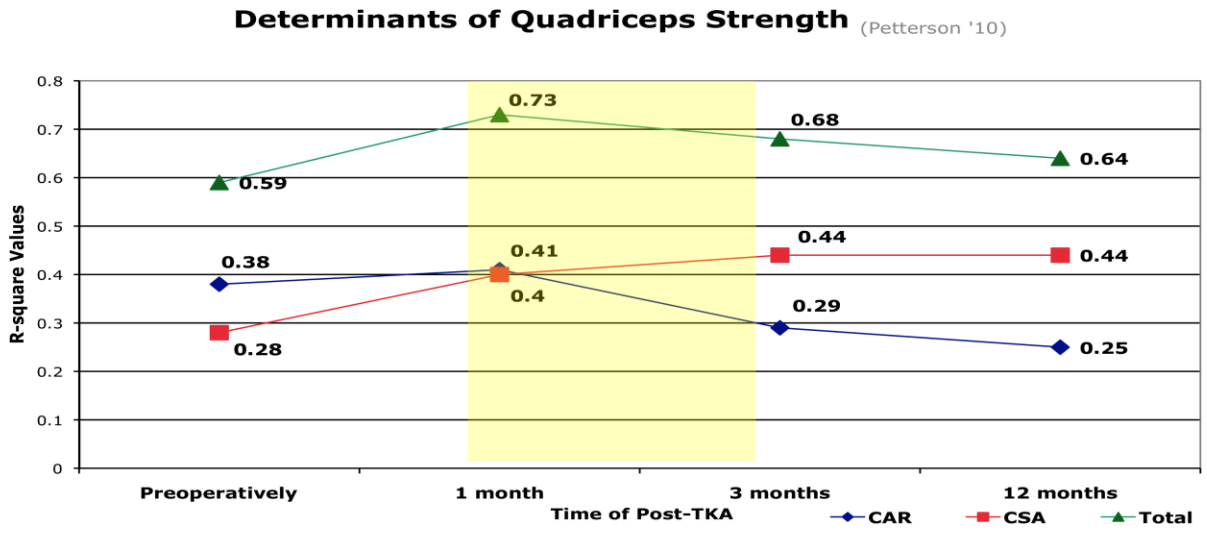
(Andriacchi 1993, 1994,Wilson 1997)

- There is a potential to improve their functional performance to the level of age-matched healthy controls.

Research Questions

"What are the most effective intervention protocols?"

- Determinants of Quadriceps Strength of the op limb
  - Voluntary Activation v.s. Lean Cross Sectional Area



Muscle Activation Deficit

- Is impaired maximum capability to activate available muscle fibers in a muscle.
    - i.e. Central Activation Ratio
- Contributes to muscle weakness in clinical populations with/without muscle atrophy.
    - HIV (Scott 2007), ACL Injury (Snyder-Mackler 1994&1995), Knee OA (Hurley 1993, Lewek 2004, Fitzgerald 2004, Stevens 2003)
    - Post-TKA (Stevens 2003, Mizner 2003&2005, Meier 2009, Petterson 2009)
        - » The primary predictor of quadriceps weakness in acute phase for individuals following TKA.
- How does it occur?

Intramuscular Adipose Tissue (IMAT)

- Increased by:
  - Inflammatory conditions (Stump 2006, Beasley 2009, Cheema 2010, Ioozo 2011)
  - Lower mobility level (Manini 2007, Goodpaster 2008, Reid 2011)
  - Aging (Goodpaster 2001, Song 2004,Vettor 2009)
- Related to muscle weakness
  - Yet independent from lean tissue (Delmonino 2009, Reid 2011)

"IMAT may inhibit muscular force production in older adults as a potential modulator of central activation."

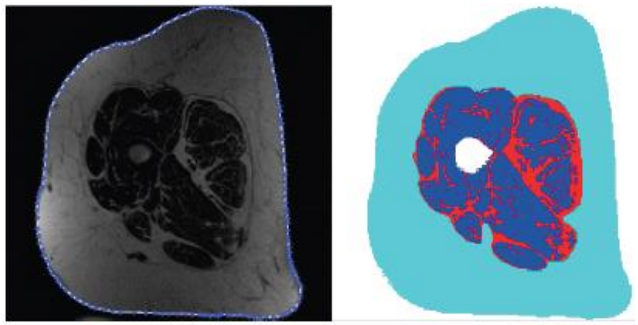
IMAT is inversely related with central activation of quadriceps femoris.

Project 2

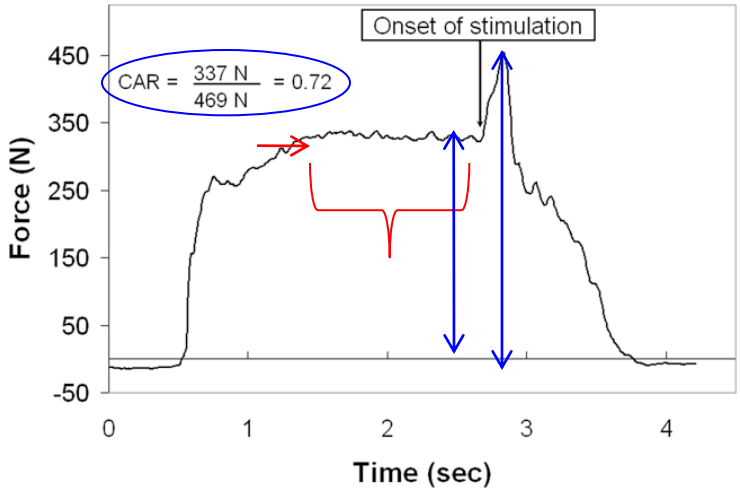
- 15 older adults (N=29 legs, 70.5 ± 10.6 y.o, BMI 28.3 ± 6.6 kg/cm2)

- MRI
  - 3-point Dixon Water Analysis
    - MatLab and Labview
    - High reliability and validity

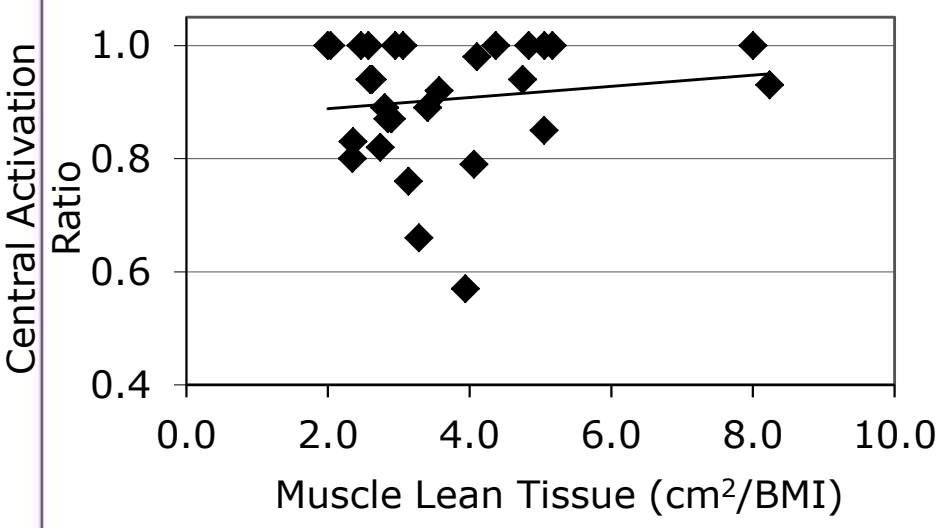
      (Elder 2004, Dibble 2006, Gorgey 2007)



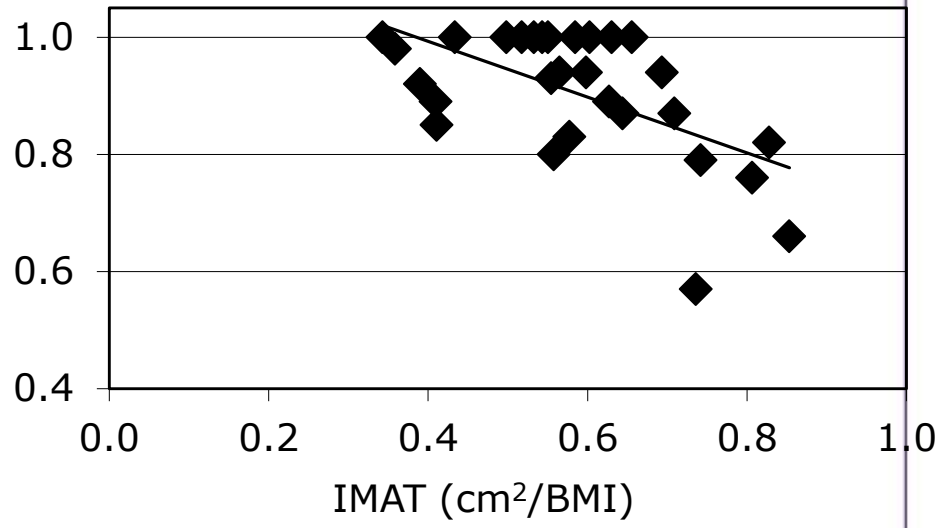
- Muscle Activation
  - Supraimposed technique
    - KinCom 500H,Grass Stimulator
  - Central Activation Ratio



Results



(rho=0.068, p=0.724)



(rho=-0.511, p=0.005)

- CAR 0.91 (± 0.11)
- Lean Tissue 3.58 (± 1.57) cm^2/BMI
- IMAT 0.57 (± 0.16) cm^2/BMI

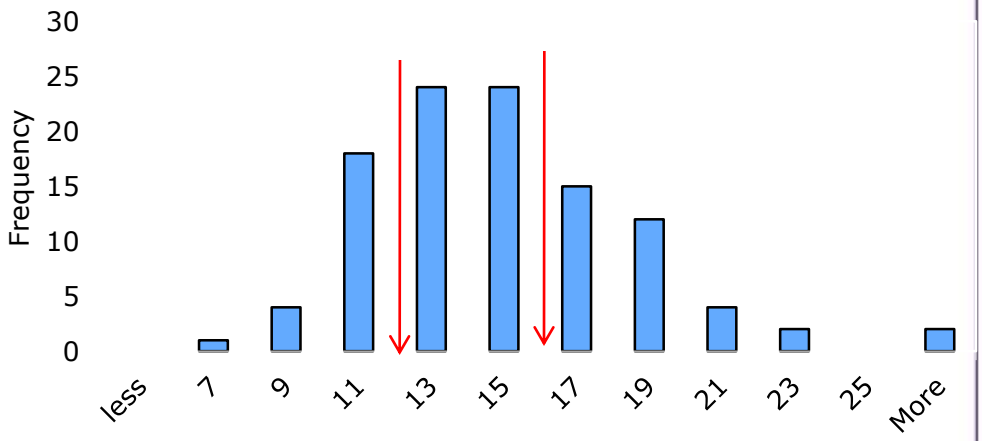
Exploratory Question

- Do individuals with high IMAT have lower muscle activation?

http://farm6.staticflickr.com/5217/5471047557_4dc13f5376.jpg

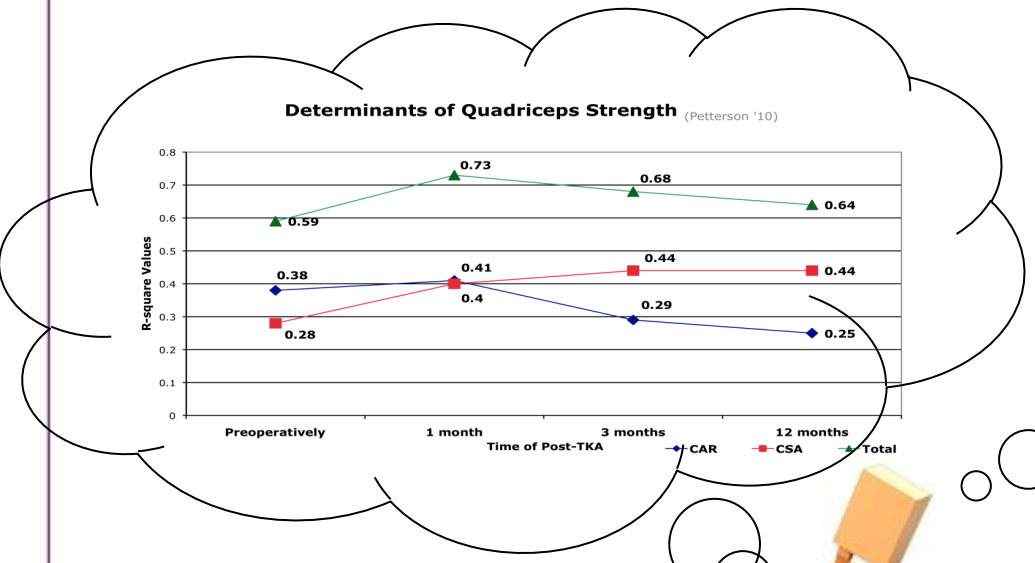
- 160 images from SMERF lab at U of Utah.
  - low-IMAT 11.4% (25th)
  - high-IMAT 15.4% (75th)

- Sub-group
  - High-IMAT (N=6)
    CAR 0.87(± 0.11)
  - Low-IMAT (N=9)
    CAR 0.95(± 0.04)



(Yoshida et al In Review)

Now, What Can We Do?



http://www.myjewishlearning.com/blog/rabbis-without-borders/files/2011/11/thinking-man.jpg

http://1.bp.blogspot.com/-TAMfJs0VL4o/TfFXrglwr_I/AAAAAAAACJg/o7AlGQW71OI/s1600/Killing+Two+Birds+with+One+Stone.jpg

Eccentric Contraction

Eccentron©

- Effective Strength Gain
  - A function of the magnitude of the force produced.
  - Ecc exercise = "More for Less" *(LaStayo 2003)*
  - Decrease IMAT *(Marcus 2010)*
- Used with patients with varied conditions.
  - Frail elderly, patients w/ impaired central nervous disorders system, aging cancer survivors, metabolic Issues, pulmonary Disease, musculoskeletal Injury (i.e. late stage of TKA)

(LaStayo 2003, 2009, 2010, Marcus 2008, 2009, Dibble 2006, 2009, Gerber 2007, 2009)

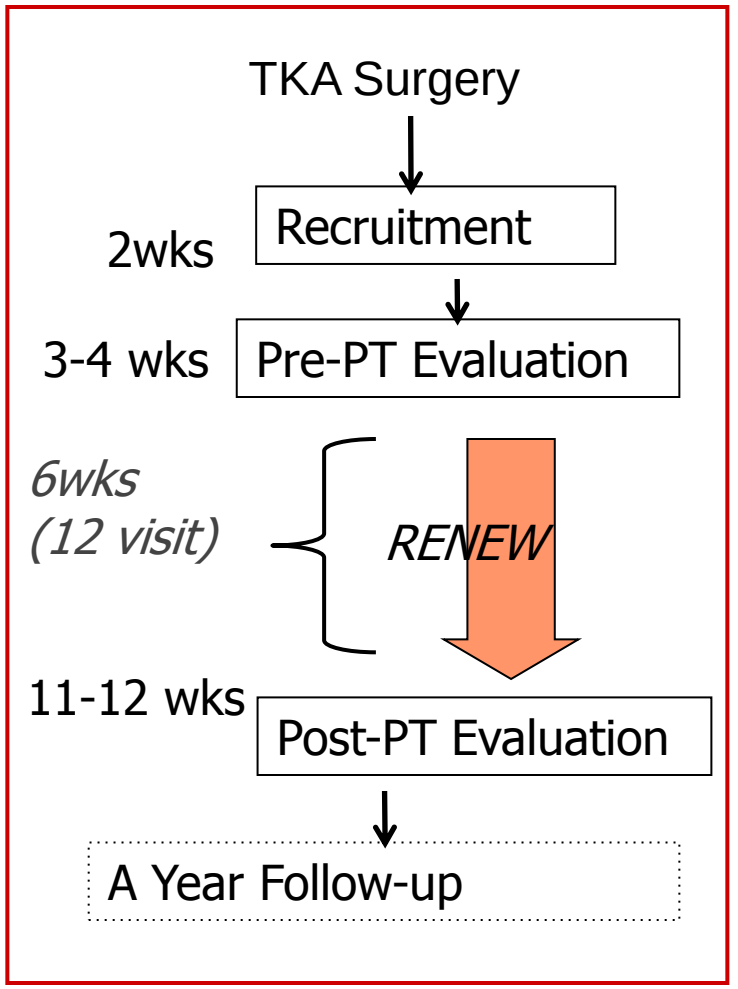
Project 3

- 13 participants after UTKA
  - Age: 56.8 y.o.
  - Height 1.70cm
  - BMI (IE:31.5, BMI: 31.8 kg/cm^2)

2 staged bilateral TKA > 6 months post-TKA from the 1st TKA

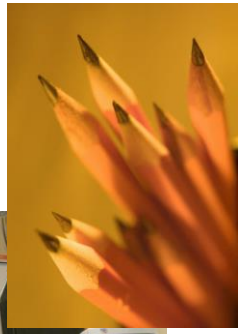
Inclusion Criteria

- Primary TKA for knee OA
- Enable to commute UOC for outpatient PT
- Enable to attain 90 degree of knee flexion at the time of recruitment (2wks post-TKA)
- Without any perceptive restrictions on daily activity

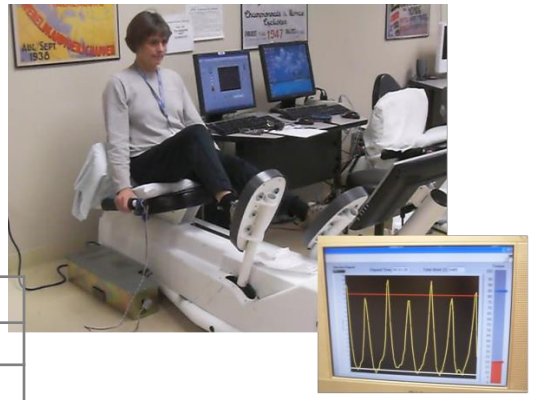


Methods

- Self-report Questionnaires
  - SF-36 Physical Component Summary
  - The Lower Extremity Functional Scale
- Mobility Tests
  - Stair Climbing Test
  - The 6-minute Walk
- Muscle Strength Tests
  - Power Output
  - MVIC of Quadriceps (Knee flexion @ 60˚)

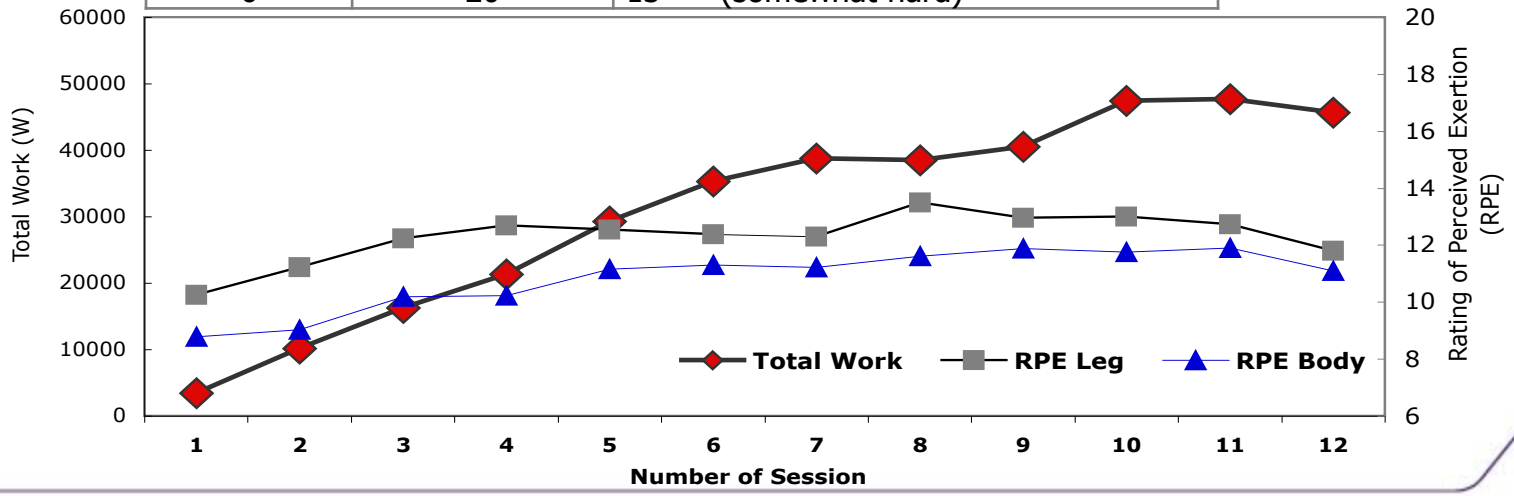



Physical Therapy Protocols



- ‘U of U’ Outpatient PT protocols (Meier 2008)
- Eccentric exercise protocols (LaStayo 2009)

Training Wk	Duration (min)	RPE
1	5	7 (very, very light)
2	6-10	9 (very light)
3	11-15	11 (fairly light)
4	16-20	11-13 (fairly light to somewhat hard)
5	20	13 (somewhat hard)
6	20	13 (somewhat hard)



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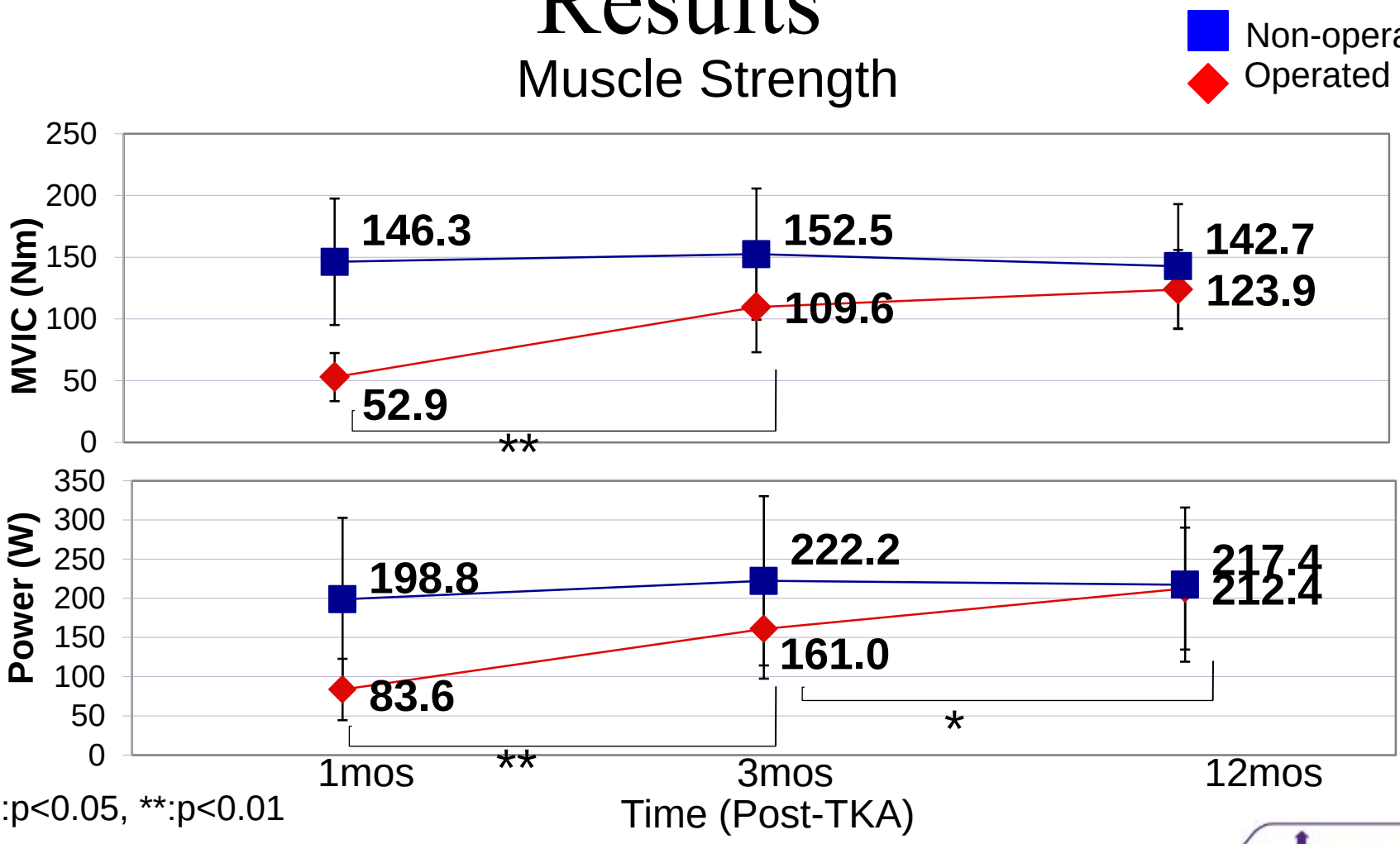
Results

Muscle Strength



*:p<0.05, **:p<0.01

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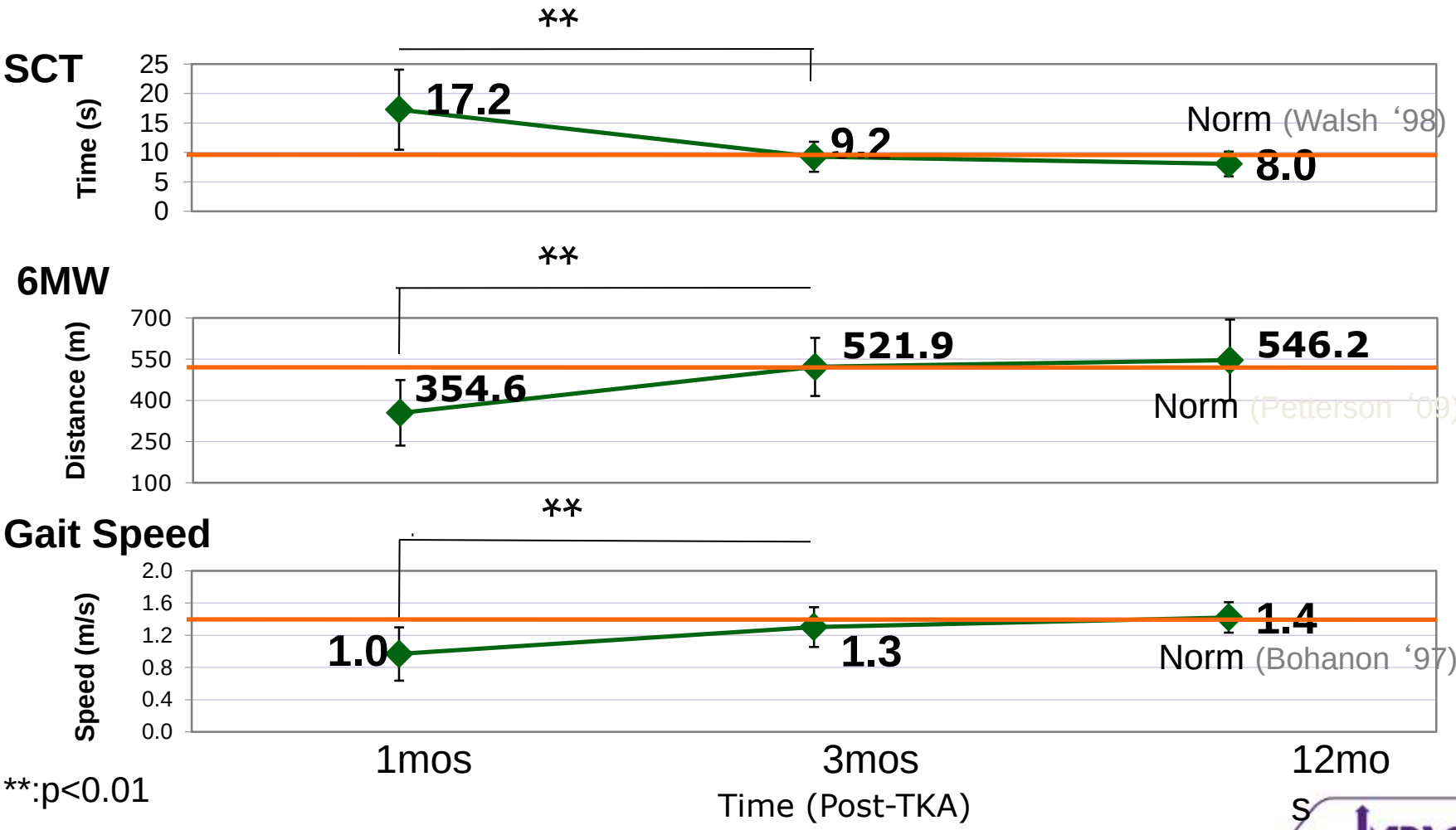
Results



**:p<0.01

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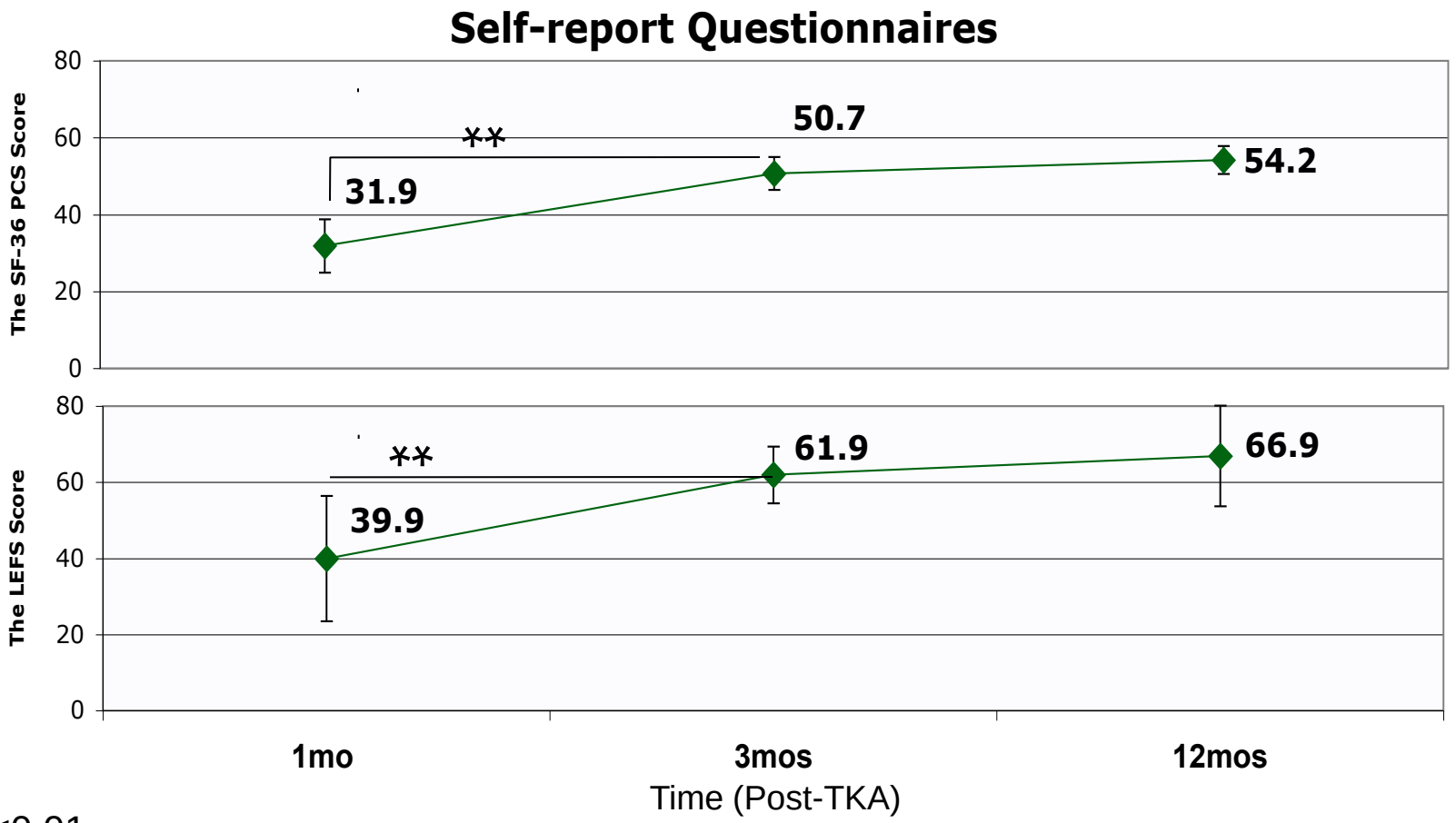
Results



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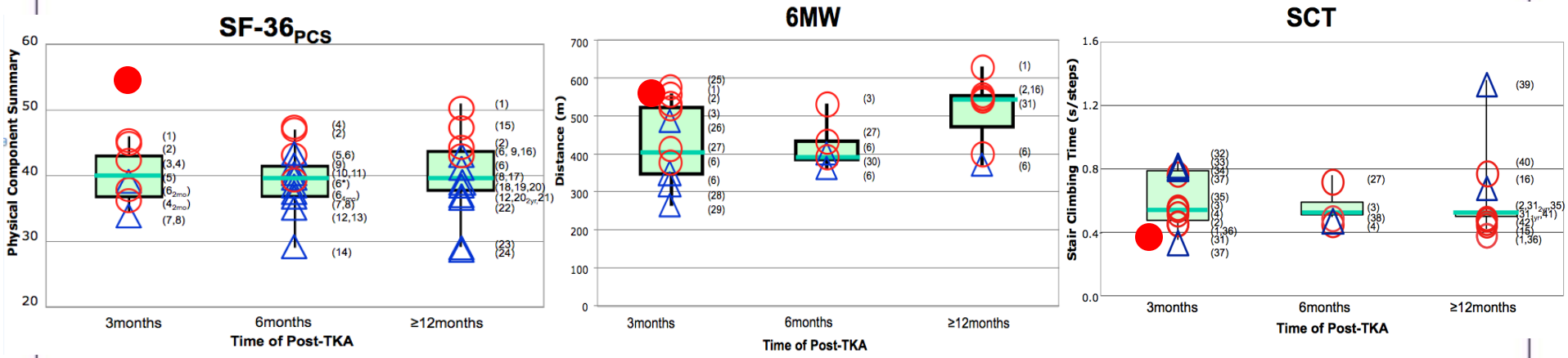


- The potential impact on best-practice rehabilitation following TKA
  - May be capable of optimizing outcomes.

Findings

1. Individuals after TKA demonstrated abnormal loading patterns during gait related to quadriceps weakness of the operated limb.
2. Impaired quadriceps function has been related to muscle structure (ie. IMAT v.s. CAR).
3. Eccentric exercise which seems beneficial to increase lean tissue and decrease IMAT resulting in mobility improvement.

   → Repetitive eccentric loadings might improve functional performance…

Future Plan

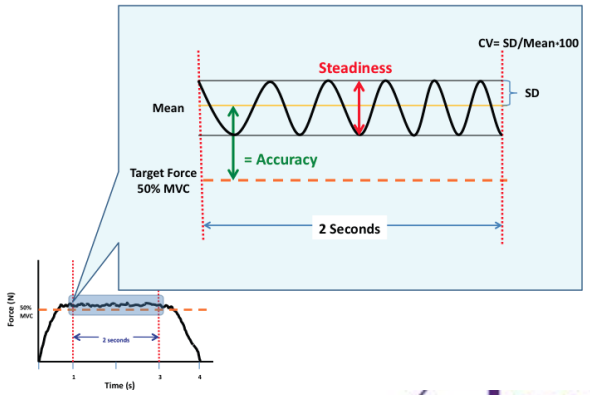
- Muscle Physiology
  - IMAT and CAR at the end stage of OA.

(Accepted by Intention letter by Deseret Foundation)

  - Ecc vs Con in force fluctuation
    - Specific contraction type exists in stair function

(Funded by Japanese PT Association)

- Gait Training



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Thank You

Any Questions?

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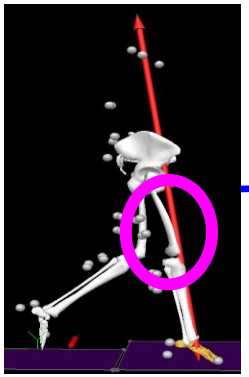
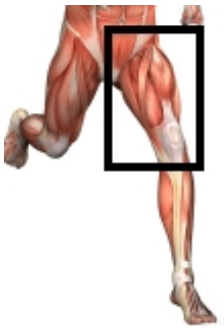
Outcome of Abnormal Gait Patterns

- Less physical stress of musculoskeletal structure of the knee.
- Persistent abnormal gait patterns may be related to persistent quadriceps weakness.



3mo



3mo

&

1 yr

http://www.abs-exercise-advice.com/images/knee-anatomy-pictures.jpg

Altered muscle recruitment patterns during gait are related to future weakness.

(In Review)

TKA		NMIVC_op 3mos		NMVIC_op 1yr	
Knee Function of the Operated Limb		R	p	R	p
Hamstrings NEMG	% MVIC				
Quadriceps NEMG	% MVIC				
Co-contraction					
Knee Extensor Moment	Nm/BW*HT				
Peak Knee Angle	degree				
Knee Flexion Excursion	degree				