The Immediate Effects of Repetitive Transcranial Magnetic Stimulation on Pain, Strength, and Function in Patients with Knee Osteoarthritis

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Celebrating the past–Endowing the future

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Introduction

Background

- Knee osteoarthritis (OA) is prevalent in over 10 million U.S. individuals, predominantly in adults >45 years[1]
- Over half of U.S. adults diagnosed with knee OA will undergo a total knee replacement[2]
- Knee OA can lead to several factors (Fig 1) including quadriceps weakness,[3] which is associated with increased pain and reduced function[4]
- Reductions in the excitability of the primary motor cortex (M1) and descending corticomotor pathways[5] could contribute to quadriceps weakness[6,7]
- Repetitive transcranial magnetic stimulation (rTMS) over M1 could improve motor function by increasing corticospinal excitability in healthy volunteers[8] and patients with stroke[9]
- rTMS may also improve chronic pain, possibly through activating distant areas in the brain involved in pain integration and modulation[10]

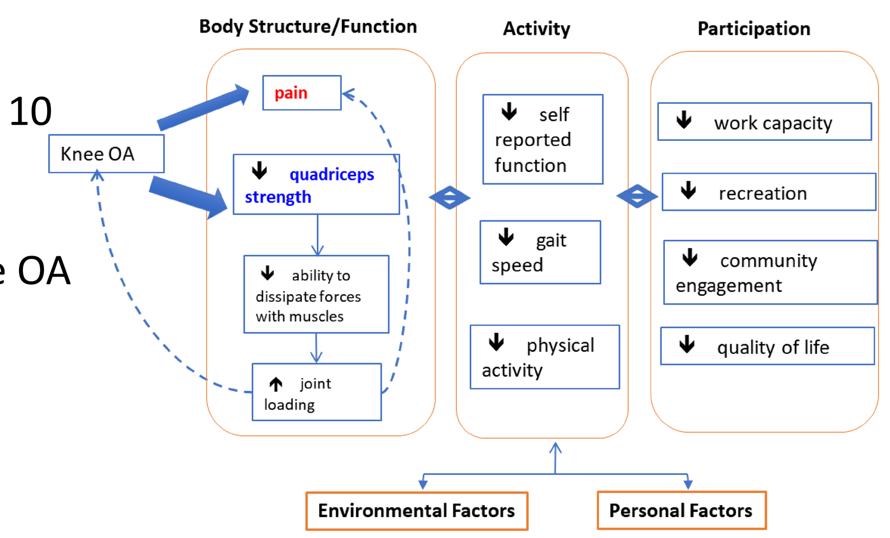

Figure 1: Implications of Knee OA

Purpose:

- Determine the immediate effects of rTMS with exercise (rTMS + EX) compared to the Sham + EX intervention on pain, quadriceps strength, and functional performance in adults with knee OA.

Methods

Setting: Neuromuscular Research Laboratory, Department of Exercise and Sport Science at UNC Chapel Hill

Subjects: Individuals aged 40 to 75 with symptomatic OA in one knee and a relatively asymptomatic contralateral knee

Exclusion criteria:

- pregnant or planning to become pregnant
- other orthopedic conditions affecting legs or spine
- history of brain injury, metal implants, cochlear implants, seizures, syncope
- medications that lower the seizure threshold

Data Collection:

- **Pain** (current and worst) on Numeric Pain Rating Scale (NPRS)
- **Strength** as maximum voluntary isometric contraction (MVIC) using HUMAC isokinetic dynamometer with knee in 70 degrees of flexion
- **Functional performance** using Timed-Up and Go (TUG) test

Data Analysis:

- Within session change scores for the dependent variables compared between rTMS + EX and Sham + EX using one-tailed paired t-tests
- P value <0.05 used to discriminate statistical significance

Double-blind, crossover study

- Subjects attended two sessions (spaced 1 week apart) in random order (Fig 2)
  - one session of *rTMS + EX*
  - one session of *Sham + EX*
- Pre/post intervention measurements to calculate within session change scores
- Corticospinal excitability measured by motor evoked potentials (MEP)
- Quadriceps active motor threshold (AMT) was determined using single pulse TMS (Magstim BiStim2) and MEP (Fig 3)

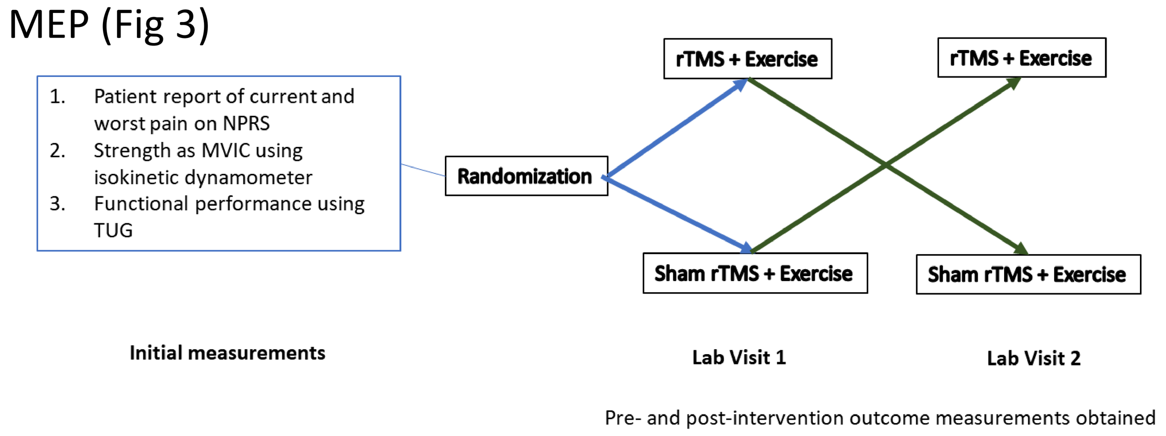

Figure 2: Crossover design

Intervention

- Subjects performed light (5% MVIC) quadriceps exercises (Fig 3)
- Using Magstim Super Rapid[2] and a double cone coil, rTMS was delivered at 10 Hz (5 sec on, 55 sec off) at 70% of the AMT for 15 minutes (Fig 4 &5)
- For *Sham + Ex*, Mu metal was positioned between the stimulation coil and the scalp to disperse the stimulation

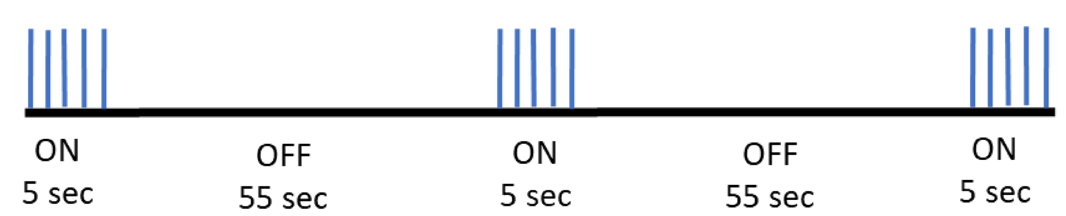

Figure 4: rTMS stimulation protocol sample

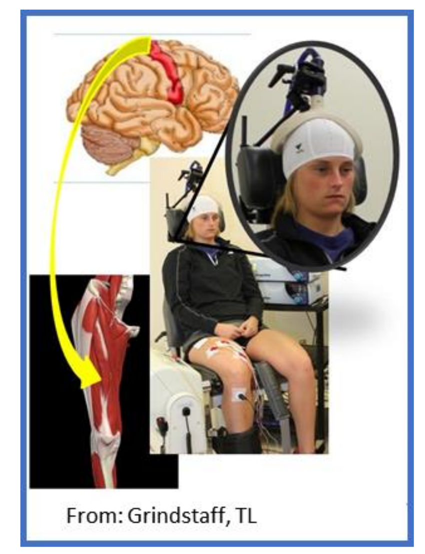

Figure 3: TMS and rTMS for Quadriceps Measures and Intervention

Results

Participants

- Data for 10 subjects (7 F, 3 M)
- Demographic data and results from selected outcome measures recorded at the initial visit are shown in Table 1 at the right

Table 1. Subject Characteristics

Characteristics	Mean ± SD	Range
Age (y)	61.4 ± 7.7	45 – 69
Height (cm)	170.37 ± 7.20	160.8 – 185.9
Weight (kg)	82.88 ± 17.35	62.4 – 114.2
BMI (kg/m^2)	28.31 ± 3.90	21.9 – 33.3
WOMAC pain	8.6 ± 7.0	0 – 22
WOMAC stiffness	5.6 ± 2.7	0 – 9
WOMAC physical function	23.2 ± 11.8	5 – 41
WOMAC total	36.6 ± 21.2	11 – 72
UCLA Activity Scale	6.2 ± 1.4	4 – 9
Pain Catastrophizing Scale	9.9 ± 9.3	0 – 30

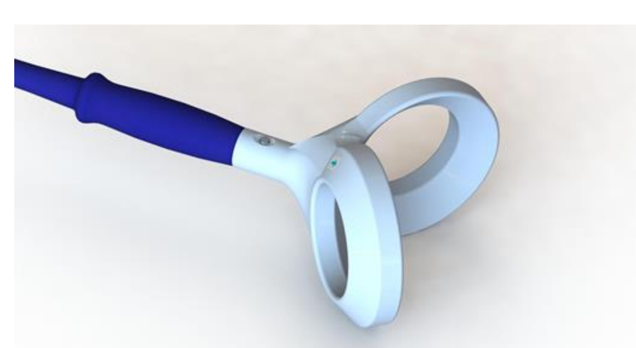

Figure 5: Double cone coil

Results of Paired t-tests (Table 2)

- Within session average change in quadriceps MVIC:
  - *rTMS + EX* torque was less (p = 0.0457) than that of *Sham + Ex*
- No differences between rTMS and Sham interventions for Pain or TUG.

Table 2: Mean pain, strength, and function changes between interventions

	# of subjects	rTMS + EX (Mean change ± SD)	Sham + EX (Mean change ± SD)	P value
Pain#	8	-0.313 ± 1.60	-0.375 ± 0.443	0.4506
MVIC (Nm/kg)	10	-3.83 ± 10.6	-8.16 ± 6.61	0.0457*
TUG (s)	10	-0.0327 ± 0.52	-0.0403 ± 0.74	0.4890

#Average of current and worst pain
*Denotes statistically significant difference

Discussion and Conclusions

- The difference in attenuation of quadriceps MVIC with *rTMS + EX* compared to *Sham+ EX* suggests that one session can produce immediate effects in post-exercise quadriceps recruitment in individuals with knee OA.
- The decrease in torque output in both groups indicates a possible fatigue effect of the exercise intervention
- One session of rTMS + EX was not sufficient to show improvements in pain and TUG performance.

Limitations

- Only 10 total subjects and incomplete pain data from two subjects
- Results are based on only one true and sham rTMS session
- Lack direct measures of corticospinal excitability

Future research

- Evaluate rTMS dosage parameters, such as number of sessions, for carryover effects beyond only one session.
- Evaluate long-term effects of rTMS on current variables in addition to quality of life and risk for future total knee replacement.

References

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