Tendinopathy and the Effectiveness of Eccentric Exercise

A Systematic Review

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Overview

- Purpose
- Introduction
- Methods
- Results
- Discussion
- Clinical Relevance
- Future Research
Purpose

To systematically review the current evidence and determine the effectiveness of eccentric exercise in the treatment of chronic tendinosis
Introduction

**Tendinosis:**
- a non-inflammatory intratendinous collagen degeneration without clinical or histological signs of inflammation\(^1,2\)

**Common tendons affected:**
- patellar, Achilles, tendons of the medial and lateral elbow, rotator cuff\(^2\)
Introduction

Prevalence

- Elite male volleyball players
  - 40% to 50% patellar tendinosis

- General population
  - Lateral epicondylitis annual incidence is between 1% - 3%

- Competitive tennis players
  - Incidence can be as high as 40%

- Elite and recreational runners
  - Achilles tendinopathies accounts for 9% of injuries

- Overuse injuries, including tendinopathies, account for nearly 7% of all injury related physician office visits in the United States
Introduction

Common causes¹:
- Aging
- Microtrauma
- Vascular compromise

Common population³-⁷:
- Competitive and recreational athletes
- People in occupations consisting of repetitive tasks or manual labor

Recovery times with treatment¹:
- Early presentation: 6-10 weeks
- Chronic presentation: 3-6 months
Introduction

**Histological Findings**

- ↑ cellularity - fibroblasts and myofibroblasts
- ↑ vascularity and ground substance
- Collagen disorientation, disorganization, focal necrosis or calcification, vascular spaces with or without neovascularization and fiber separation
- Absence of inflammatory cells
Introduction

Conservative Treatments\textsuperscript{1-8}

- Ultrasound
- Laser
- Deep friction massage
- Orthotics and braces
- Corticosteroids
- Mobilizations and manipulations
- Thermotherapy
- Cryotherapy
- Rest
- Acupuncture
- Pulsed electromagnetic field therapy
- Eccentric exercise
Introduction

Eccentric Exercise

- The active lengthening of a muscle under force$^{10}$
Introduction

- Eccentric training leads to increased net collagen synthesis in the tendon tissue through constant overload on the tendon\(^\text{11}\)

- 12 weeks of EE training normalized tendon structure and decreased tendon thickness in Achilles tendinosis\(^\text{12}\)
Introduction

RATIONALE

- The literature shows that eccentric exercise has promise for treatment of Achilles and patellar tendinopathies

GOAL

- Review the literature to examine the effectiveness of eccentric exercise as a treatment for tendinosis
Methods
**Methods: PICO**

| P | Patients diagnosed with a tendinopathy (eg. clinical exam / MRI / Ultrasound / Doctor) or chronic painful tendon greater than 3 months  
|   | Adults 16 years or older |
| I | Eccentric exercise |
| C | none |
| O | Pain  
|   | ROM  
|   | Return to functional activities  
|   | Avoid surgical intervention  
|   | Strength  
|   | Tendon structure/healing |
Methods: Search Strategy

Databases
- EMBASE
- CINAHL
- MEDLINE
- PEDro
- Cochrane library
- SPORTDISCUS

Other Forms
- Hand searching Journals
  - Physiotherapy, Physical Therapy
- Reference lists
- Personal libraries
- Communicating with experts in the field
  - Doctoral candidate (Michael Ryan)
Main Terms

- Tendinopathy, tendinosis, tendon disease, tendon injury
- Achilles, swimmers shoulder, patellar tendon, golfer’s elbow, rotator cuff, jumper’s knee
- Eccentric exercise
### Table of Search Terms

<table>
<thead>
<tr>
<th></th>
<th>Search Terms</th>
</tr>
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<tbody>
<tr>
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<td>3</td>
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</tr>
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<td>4</td>
<td>Tend#n disease.mp</td>
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<td>Rotator cuff tend$.mp</td>
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<td>8</td>
<td>Shoulder injury.mp</td>
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<td>11</td>
<td>Tennis elbow/or lateral epicondyle$ injury.mp</td>
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<td>12</td>
<td>Golfer's elbow.mp</td>
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<tr>
<td>13</td>
<td>Patella$ tend$.mp</td>
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<td>Jumper’s knee.mp</td>
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<td>Achilles tend$.mp</td>
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<td>Eccentric.mp</td>
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<td>Exercise.mp or Exercise/</td>
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<td>18</td>
<td>Or/ 1-15</td>
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<tr>
<td>19</td>
<td>16 and 17</td>
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<tr>
<td>20</td>
<td>18 and 19</td>
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<tr>
<td>21</td>
<td>Limit 20 to (human and English language)</td>
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</table>
Methods: Study Selection

Inclusion Criteria
- 16 years or older
- Clinical diagnosis of tendinopathy or:
  - Tendon pain for > 3 months
- English studies
- Eccentric Exercise

Exclusion Criteria
- Concurrent treatment
- Surgical intervention
- Tendinosis caused by injection
Methods: Study Selection

Study Selection

- Screen of title and abstracts
- Selection of articles based on inclusion criteria
  - 2 person independent review
- Recovery and review of full articles
  - Random allocation to 2 persons for independent review
Methods

Study Selection

- Pilot the data extraction form
  - Modified data extraction form provided by Dr. Linda Li
  - 10% of articles were tested using the form
    - 89.6% based on 115 variables
  - Changes were made to the form to increase accuracy and consistency
Methods

Data extraction

- Study description
- Participant description
- Study quality rating (van Tulder\textsuperscript{13})
- Baseline and post treatment outcome measurements
- Dropouts, adverse effects
Methods: Quality of Studies

- Used Van Tulder\textsuperscript{13} Quality Assessment
  - 11 criteria rated: Yes, No, Unclear
- Methodological criteria were independently assessed by 2 reviewers
- Consensus reached by discussion
- High Quality = Score of 6 of 11 or above
- Low Quality = Score 5 and below
Less than 1/3 of the studies fulfilled all of the following criteria:

- adequate treatment allocation concealment, blinding of patients, and blinding of the care provider

Less than 1/2 of the studies blinded the outcome assessor to the intervention or had acceptable compliance (> 70%) in all groups.
Methods

- **Standard mean differences**: Hedge’s G
  - Studies with similar outcome measures

- **Best evidence synthesis\(^{14}\)**
  - Rates studies according to whether: Strong, moderate, limited, indicative, no evidence
  - Utilizes study design (RCT, CCT, other design), study quality (high/low), statistical findings
Results
Study Selection

201 citations

16 relevant articles
Search of databases: (n =201)
  EMBASE [56]
  Sportdiscus [48]
  CINHAL [47]
  MEDLINE [41]
  Cochrane Library RCT [13]
  PEDro [5]

Duplicate articles excluded: (n = 91)

Articles excluded based on title/abstract (n = 80)

Articles retrieved for detailed evaluation (n = 30)

Excluded articles: (n=29)
- Not an RCT or CCT (n=18)
- Failed eligibility criteria (n=8)
- No eccentric exercise intervention (n=1)
- Language (n=1)
- Not found (n=1)

Added studies based on personal libraries, checked references and hand searching: (n = 15)

Final selection included in systematic review: (n= 16)
  RCT: (n = 12)  CCT: (n = 4)
Results: Brief Summary of Included Studies

- **Patellar tendon** N = 6
  - Age range: 22-31 years

- **Achilles tendon** N = 7
  - Age range: 39-51 years

- **Wrist extensors** N = 3
  - Age range: 38-47 years
Results: Heterogeneity of studies

- **Eccentric Exercise (EE):** variety of exercises
  - some protocols have participants exercising through moderate amounts of pain

- **Comparative Treatments (CT):**
  - Concentric exercise, night splint, stretches, shock wave therapy, TENS, US, DTFM, control

- **Duration of symptoms:** 3-41 months
- **Duration of Intervention:** 4-24 weeks
- **Number of participants:** 15-124 persons
- **Types of participants:**
  - Recreational athletes (4 studies)
  - Competitive university volleyball players (5 studies)
  - General population
Outcome Measurements

ICF Classification

Body function and structure:
- Pain and strength

Activity:
- Functional assessments and questionnaires such as:
  - Victorian Institute of Sport Assessment (VISA)
  - Foot and Ankle Outcome Score (FAOS)
  - Pain free grip (PFG)
  - The Disabilities of the Arm, Shoulder and Hand (DASH)
  - Grip strength, global assessments, performance measurements

Participation:
- Quality of life questionnaires and return to sport
Included Studies

12 RCTs$^{3,15-24}$

- 7 studies rated as high quality (range 6-8)
- 5 studies rated as low quality (range 3-5)

4 CCTs$^{25-28}$

- 1 study rated as high quality (score 7)
- 3 studies rated as low quality (range 2-5)
Results

- Calculated the Standard Mean Difference (SMD) between the EE intervention and the CT

* could only calculate SMD on 9 of 16 studies due to lack of data

- Applied these findings to a best evidence synthesis model
## Results: SMD achilles Tendon

<table>
<thead>
<tr>
<th>Author</th>
<th>Design</th>
<th>Pain SMD</th>
<th>Strength SMD</th>
<th>Functional Assessment SMD</th>
<th>Health related QoL SMD</th>
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</thead>
<tbody>
<tr>
<td>Alfredson et al. (1998)</td>
<td>CCT</td>
<td>1.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>iii) 0.65</td>
<td></td>
<td></td>
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<tr>
<td>Rompe et al. (2007)</td>
<td>RCT</td>
<td></td>
<td></td>
<td></td>
<td>ii) EE vs CT: 1.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ii) 0.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roos et al. (2004)</td>
<td>RCT</td>
<td></td>
<td>i) EE vs EE + splint: 0.47</td>
<td>ii) EE vs splint: 0.69</td>
<td></td>
</tr>
</tbody>
</table>
## Results: SMD patellar tendon

<table>
<thead>
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<th>Author</th>
<th>Design</th>
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<th>Health related QoL SMD</th>
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<tr>
<td><strong>Patellar Tendinosis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Jonsson and Alfredson (2005)</td>
<td>RCT</td>
<td>1.98</td>
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<tr>
<td>Purdam et al. (2004)</td>
<td>CCT</td>
<td>1.79</td>
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# Results: SMD wrist extensors

<table>
<thead>
<tr>
<th>Author</th>
<th>Design</th>
<th>Pain SMD</th>
<th>Strength SMD</th>
<th>Functional Assessment SMD</th>
<th>Health related QoL SMD</th>
</tr>
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<tbody>
<tr>
<td>Wrist Extensor tendinosis</td>
<td>2.39</td>
<td>ii) 1.02</td>
<td>iii) 2.14</td>
<td></td>
<td>1.04</td>
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<tr>
<td>Croisier et al. (2001)</td>
<td>CCT</td>
<td>2.39</td>
<td></td>
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</table>
Results: Best Evidence Synthesis

Tool used to comment on the strength of the results based on:

1. Statistically significant findings from the calculation of the SMD
2. The study design (RCTs or CCTs)
**Best Evidence Synthesis**

<table>
<thead>
<tr>
<th>Limited Evidence</th>
</tr>
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<tbody>
<tr>
<td>➢ Statistically significant findings in outcome measures in at least one high quality RCT, OR</td>
</tr>
<tr>
<td>➢ Consistent statistically significant findings in outcome measures in at least two high quality CCTs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicative Findings</th>
</tr>
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<tbody>
<tr>
<td>➢ Statistically significant findings in outcome and/or process measures in at least one high quality CCT or low quality RCT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No Evidence</th>
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<tbody>
<tr>
<td>➢ Results of eligible studies do not meet the criteria for one of the above stated level of evidence, OR</td>
</tr>
<tr>
<td>➢ In the case of conflicting results among RCTs and CCTs</td>
</tr>
</tbody>
</table>

Table adapted from Steultjens et al. 2002
Results: Best Evidence Synthesis

Achilles

**Limited evidence** for the effectiveness of EE interventions on functional ability

**Limited evidence** for the effectiveness of EE interventions on increasing health-related quality of life when compared to a “wait and see” control group

**No evidence** to support the effectiveness of EE on decreasing pain or on increasing strength when compared to CT – due to conflicting findings
Results: Best Evidence Synthesis

Patella

**Indicative findings** for the effectiveness of EE interventions on pain outcomes over other CTs.

**Indicative findings** for the effectiveness of EE interventions on functional ability versus CTs.

**No evidence** was found for the effectiveness of EE interventions on strength when compared to CTs.
Results: Best Evidence Synthesis

Wrist extensors

**Indicative findings** that EE interventions are effective for improving the patient’s quality of life over other CTs.

**No evidence** for the effectiveness of EE interventions on decreasing pain or increasing strength when compared against CTs (due to conflicting findings).
Discussion
General Limitations

**Study design**
- Intervening variables:
  - EE with concentric component (2 studies)
  - Treatment & control treatment groups share co-treatments (4 studies)
- Poor control of intervention:
  - Monitoring adherence, controlling progression
- Underpowered:
  - 12/16 studies with sample populations < 50
  - Inability to conduct meta-analysis or sub group analysis due to heterogeneity
- Lack of true controls
  - Use control treatments for comparison so does not examine absolute effectiveness of EE. Limits findings to effectiveness of EE versus alternative treatment.
- Outcome measures
  - Non-validated and non-standardized preventing comparisons & weakening findings
General Limitations

- **Study Quality Shortcomings** (van Tulder criteria\(^{13}\))
  - Description of randomization
  - Concealment of treatment allocation
  - Blinding outcome assessors
  - Intention to treat analysis
- **Reporting**
  - 7 out of 16 studies excluded from best evidence synthesis due to lack of data
- **Generalizability**
  - 8 out of 16 studies use young, elite athletes
Eccentric Exercise: What is an optimal Protocol?

- Differences of opinion persist as to optimal exercise intervention
- 9 out of 16 studies use intervention based on Alfredson protocol (Alfredson 1998) 
  - 2 x/day
  - 7 days/week
  - 3 x 15 reps
  - 12 week intervention
  - Exercise with pain (VAS score varies)
  - Progression with added weight
Eccentric Protocol

- Alfredson model is based on clinical experience and lacks a scientific basis\(^{29}\)
- Croisier et al. (2007) found good results in a well controlled study training subjects 3 x/week versus 7 x/week

- They argue that an optimal prescription involves periods of rest to allow for recovery from post exercise weakness
Eccentric Protocol: How much pain?

- Alfredson et al. (1998) suggest that pain is an essential component of their successful intervention in AT

- Curwin and Stanish (1984) achieve good results with a painless protocol in PT and LET\(^3,^{17,28}\)

- For LET, researchers argue against training into pain claiming that it may have a negative impact on patient compliance and provoke injury\(^21,28\)
Clinical Relevance

- Overall, the studies demonstrate a positive trend in favour of EE.
- Clinicians must consider whether the subjects studied are representative of their patient population and whether the EE intervention is realistic, particularly when considering prescribed loads, frequency and intensity of pain with exercise.
Future Research Design

- Better research design
- Consistent/validated Outcome Measures
- Larger samples
  - Allow subgroup analysis to uncover the impacts of factors such as age, sex, activity, biomechanical faults, and duration or severity of symptoms
- Post treatment assessments
  - To determine long-term impact
Future Research Topics

- Improve understanding of physiological effect of EE on the muscle tendon unit & whether this varies by tendon
- Optimal EE intervention
- Impact of intrinsic & extrinsic factors on occurrence of tendinosis
  - Intrinsic (e.g. age, gender, biomechanics, genetics)
  - Extrinsic factors (e.g. environment, physical load, training errors)
- Improved understanding of the pathophysiology of tendinosis across tendons
Conclusion

- This review demonstrates a lack of well designed high quality studies providing limited evidence to support the clinical effectiveness of EE over other conservative treatments in the rehabilitation of tendinosis.
Acknowledgements

A great BIG Thanks to Dr. Linda Li and Charlotte Beck for their help with this project
Questions?
References


