Re-thinking the foot: what about exercise rehab?

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Stiffness

Propulsion

Flexibility

Load absorption

(Kelly 2015)
Extrinsic

Intrinsic

(McKeon 2015; Kelly 2015)

Neural

Active

Passive

Extrinsic
Intrinsic foot muscles

**Deep**
- Plantar interossei
- Adductor hallucis
- Flex hallucis brevis
- Flex digiti minimi

**PLANTAR**
- Quadratus plantae
- Lumbricals

**Superficial**
- Abductor hallucis
- Abductor digiti minimi
- Flex digitorum brevis

**DORSAL**
- Ext hallucis brevis
- Ext digitorum brevis
- Dorsal interossei
Why train the foot muscles?

- Neural
- Active
- Passive
Intrinsic foot muscles deficits

**Plantar heel pain**
- Reduced muscle volume rearfoot (Cheung 2016)

**Chronic ankle instability**
- Reduced muscle volume AddH & FHB (Feger 2016)

**Hallux valgus**
- Reduced size AbdH & FHB (Lobo 2016; Stewart 2013)

**Diabetes mellitus**
- Reduced muscle volume (Bus 2002; Andersen 2004)
- Reduced size EDB & 1st IS (Morrison 2018)
How to detect?

**MRI**
(Chang 2012; Cheuy 2013)

**Ultrasound**
(Crofts 2014; Franettovich Smith 2017)

**Morphology**
How to detect?

**Strength**

Toe dynamometry & load cells
(Uritani 2014; Quek 2015; Nix 2012; Fraser 2017; Ridge 2017)
How to detect?

**Intrinsic foot muscles test**
(Sauer 2011; Facchini 2015)

**Intrinsic positive test**
(Garth 1989)

**Paper grip test**
(de Wim 2002)

**Rating of motor performance**
(Fraser 2017)
How do we train?

- Google search
- “foot exercises”
  - 531,000,000 results

73 papers in PUBMED
What exercises are described?

- Toe curl
- Archxerciser
- Short foot exercise
- Toe extension
- Toe spread out
Which muscles are recruited?

Interossei and lumbricals
Flexor hallucis brevis
Adductor hallucis oblique
Flexor digiti minimi
Quadratus plantae
Abductor digiti minimi
Flexor digitorum brevis
Abductor hallucis

Measurement fMRI: % activation
Which muscles are recruited?

(Jung 2011; Kim 2013; Goo 2014)

- SFE 45% MVC
- Toe curl 10% MVC
  vs
- TSO (90% MVC)
- SFE (45% MVC)

Abductor hallucis

Measurement SEMG

Standing

Sitting
Effective strengthening?

8 week intervention
May provide additional benefit to orthoses

- Abductor hallucis size
- Toe flexor strength

(Jung 2011)
Healthy

(Kim 2015)
HV

6 week intervention

- Abductor hallucis size
- Toe flexor strength

(Unger 2000)
Healthy
Effective strengthening?

12 week intervention
Supervised progressive toe flexor training
Vs home exercise program vs control

Toe flexor strength
Limitations / Gaps in the literature

Outcome measures: Strength or morphology

Control group comparison

Muscles of interest

Patient populations

Dosage

Specific vs general training
Other types of exercise / intervention?

High load training
(Rathleff 2015)

Electrical stimulation
(Fourchet 2009)

Footwear
(Johnson 2016; Chen 2016; Mullen 2014; Miller 2014; Glodman 2013)
Summary: Evidence + clinical opinion

“FROM ISOLATION TO INTEGRATION” (McKeon 2015)

Foot core isolation

Patient response

Foot core integration

Passive interventions

Variety of exercises to target different muscles

Progression – task (load) & environmental demands
THANK-YOU!

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