Professions currently engaged in research projects

- Podiatrists
- Physiotherapists
- Orthotists
- Prosthetists
- Sports therapists
- Orthopaedic Surgeons
- Occupational therapists
- Osteopaths
- Speech and language therapists
Introduction

- A number of authors have suggested that a decline squat in comparison to a flat squat produces a significant improvement in the ability of the individual to participate in sports and a reduction in pain (Purdam, 2005; Jonsson and Alfredson, 2005).

- The technique was based on performing a squat with the eccentrically controlling limb placed on a 25º decline.
Purdam et al, 2005

- Purdam demonstrated the effect of an eccentric decline squat in the management of painful chronic patellar tendinopathy.

- Patients with patellar tendinopathy underwent eccentric squats on a decline board.

- This produced encouraging results in terms of pain reduction and return to function in the short term.

- Eccentric exercise using standard single leg squats in a similar sized group appeared to be a less effective form of rehabilitation in reducing pain and returning subjects to previous levels of activity.
Purdam et al, 2005

Professor Jim Richards
Conducted a prospective study, athletes with jumper’s knee were randomised to treatment with either painful eccentric or painful concentric quadriceps training on a decline board.

In the eccentric group, for 9/10 tendons patients were satisfied with treatment, VAS decreased from 73 to 23, and VISA score increased from 41 to 83.

In the concentric group, for 9/9 tendons patients were not satisfied, and there were no significant differences in VAS and VISA scores.

Eccentric, but not concentric, quadriceps training on a decline board, seems to reduce pain in jumper’s knee.
Jonsson and Alfredson, 2005
The basis for using a 25º decline was that by forcing the ankle in to passive plantar flexion the active calf tension is reduced therefore reducing the work done about the ankle.

However there is no scientific justification given as to why 25º was chosen for the decline angle.
A Biomechanical Investigation of a Single-Limb Squat: Implications for Lower Extremity Rehabilitation Exercise

Jim Richards, PhD; Dominic Thewlis, BSc; James Selfe, PhD; Andrew Cunningham, MSc; Colin Hayes, BSc

University of Central Lancashire, Preston, United Kingdom
Methods

- Four decline angles were selected 0, 8, 16 and 24 degrees
- The order of the declines angles was randomised
- 10 participants were instructed to perform a single limb dip or squat.

Figure 2. Experimental set-up of the board and participant performing the tests at A, the start position and B, the point of maximum knee flexion.

Professor Jim Richards
Methods

- Movement analysis data were collected using a six camera ProReflex system at 100Hz.
- The markers system used for the collection of the movement analysis data was based on the calibrated anatomical systems technique (CAST).
- Force data were collected using an AMTI force plate.
- Electromyography (EMG) were collected from rectus femoris and gastrocnemius using a DELSYS Bagnoli system.
RESULTS
Segment angles and moments at different declines

a) 0 decline  
b) 8 decline  
c) 16 decline  
d) 24 decline
Knee Joint Angle

Maximum Knee Joint Angle

0 degrees  8 degrees  16 degrees  24 degrees

62  64  66  68  70  72  74

Professor Jim Richards
Knee Moments

Maximum Knee Joint Moments

Professor Jim Richards
Rectus Femoris Activity

Rectus Femoris Activity

0 degrees
8 degrees
16 degrees
24 degrees

Professor Jim Richards
Ankle Moments

Maximum Ankle Joint Moments

Professor Jim Richards
Discussion

- The knee moments and the Rectus Femoris activity were increased with the increase in decline angle.

- The ankle moments were reduced, however the EMG activity for the Gastrocnemius disproportionately increased at 24 degrees.

- If the clinical reasoning for the test is to target the knee extensor mechanism, then both the Gastrocnemius and the Rectus Femoris activity then 16 degrees has the maximum effect at the knee with the minimum effect about the ankle.

- A decline angle of 24 degrees would only be justified if the aim was to challenge the stability at the ankle while also challenging the knee.

- Such information needs to be considered when using single limb squats clinically.
So what is the effect of Double Limb Squatting and What happens when we Stretch at different angles?
Methods

- A new product “The Rehab Angel” was developed by Neil Frame, an NHS podiatrist with R&D funding from Trustech NHS Innovation Hub

- Six plantarflexion angles were selected, 0, 5, 10, 15, 20 and 25 degrees

- The Rehab Angel also has the option of flat or 5 degree wedged surface.
18 participants performed three squats and three stretches at each angle.

Data collection was the same as the previously published work.

Electromyography (EMG) were collected from:
- biceps femoris
- rectus femoris
- gastrocnemius
- tibialis anterior

The aim was to determine if a double limb squat is affected in the same way as the previous study and to determine if any co-contractions are occurring.
Ankle Range of Motion

Ankle Motion

- Wedged Surface
- Flat surface

0 deg | 5deg | 10 deg | 15 deg | 20 deg | 25 deg

Professor Jim Richards
Ankle Moments

Ankle Moments

Moments (Nm/kg)

0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45

0 deg 5 deg 10 deg 15 deg 20 deg 25 deg

Professor Jim Richards
Ankle EMG

Tibialis Anterior iEMG

IEMG (mvs)

Wedged Surface

Flat surface

0 deg, 5 deg, 10 deg, 15 deg, 20 deg, 25 deg

Professor Jim Richards
Knee Angle

---

**Professor Jim Richards**
Knee Moments

Knee Moments

Moments (Nm/kg)

- Wedged Surface
- Flat surface

Professor Jim Richards
EMG

Rectus Femoris iEMG

IEMG (mV/s)

0.90
0.80
0.70
0.60
0.50
0.40

0 deg 5 deg 10 deg 15 deg 20 deg 25 deg

- Wedged Surface
- Flat surface

Professor Jim Richards
EMG

**Gastrocnemius iEMG**

![Bar chart showing iEMG (mvs) for Gastrocnemius muscle with different incline angles on Wedged Surface and Flat surface]

- **IEMG (mvs)**
- **Y-axis:** 0.40 to 0.80
- **X-axis:** 0 deg, 5deg, 10 deg, 15 deg, 20 deg, 25 deg

**Biceps Femoris iEMG**

![Bar chart showing iEMG (mvs) for Biceps Femoris muscle with different incline angles on Wedged Surface and Flat surface]

- **IEMG (mvs)**
- **Y-axis:** 0.40 to 0.90
- **X-axis:** 0 deg, 5deg, 10 deg, 15 deg, 20 deg, 25 deg

Professor Jim Richards
Discussion

- As the decline angle increases the ankle range of motion also increases with greater movement into plantarflexion. The ground reaction force moves closer to the ankle joint and therefore reduces the dorsiflexion moments.

- The use of the wedged surface allows a further reduction of the loads at the ankle.

- The knee range of motion also increases as the decline angle increases, however with the knee the moments also increase. Rectus Femoris activity increases as the moment increases which would indicate a graduated increase in the load at knee.

- Hamstrings activity also increases, which may be a compensatory mechanism to stop the femur moving forwards over the tibia.
ECCENTRICS and STRETCHING of the ACHILLES
Alfredson, 2005

- Eccentric calf-muscle training Curwin and Stanish (1984) stressed the importance of eccentric training as a part of the rehabilitation of tendon injuries.

- Alfredson designed a special type of eccentric calf-muscle-training regimen on patients with chronic painful mid-portion Achilles.

- In Alfredsons’ model of eccentric training, the patients were told to do the exercises despite having pain in the tendon, and when there was no pain, they were told to increase the load to reach a new level of painful training.
Alfredson, 2005
Alfredson, 2005

Eccentric calf-muscle training

- From an upright body position and standing with all body weight on the front half of the foot, with the ankle joint in plantar flexion lifted by the non-injured leg.

- The calf muscle is loaded eccentrically by having the patient to lower the heel beneath the lever.

- Eccentric calf muscle loading with the knee straight and to maximize the activation of the soleus muscle.
But how much stretch or eccentrics?

and

What happens to the biomechanics and muscle action?
Methods

- Six angles were selected, 0, 5, 10, 15, 20 and 25 degrees
- With the flat and 5 degree wedged surface.
- This time it was used to push the foot into dorsiflexion
Ankle Dorsiflexion

Ankle Angle

Angle (degrees)

0 deg 5deg 10 deg 15 deg 20 deg 25 deg

Wedged Surface
Flat Surface

Professor Jim Richards
Ankle Moments

![Ankle Moments Graph]

- **Moments (Nm/kg)**
- **0 deg, 5deg, 10 deg, 15 deg, 20 deg, 25 deg**

- **Legend**:
  - Wedged Surface
  - Flat Surface

Professor Jim Richards
Knee Angle

Knee Angle

Legend:
- Wedged Surface
- Flat Surface

Legend:
- Wedged Surface
- Flat Surface

Angle (degrees)

Professor Jim Richards
EMG

Biceps femoris

Moments (Nm/kg)

Professor Jim Richards
Medial Gastrocnemius

Moments (Nm/kg)

- Wedged Surface
- Flat Surface

Professor Jim Richards
Discussion

- Angles of inclination up to 20 degrees moves the ankle into greater dorsiflexion, with associated increasing moments but without any significant increase in iEMG values in the posterior muscles.

- Therefore we can conclude that up to 20 degrees the Rehab Angel provides a progressive lengthening force to all the structures posterior to the ankle and knee joints.

- Above 20 degrees, gastrocnemius and biceps femoris activity increases implying that it is no longer a passive stretch.

- The use of the wedged surface increases the movement towards extension and therefore offers an additional stretching component.
Conclusion

- The RehabAngel appears to offer a controlled graduated rehabilitation environment for lower limb stretching and squatting tasks.

- It is very important to consider compensatory mechanisms when studying clinical tests.
Thanks for listening

Any Questions?