Measuring muscle strength in arthroplasty patients - which method is best?

Karen Barker PhD MCSP
Clinical Director
Nuffield Orthopaedic Centre NHS Trust
Oxford

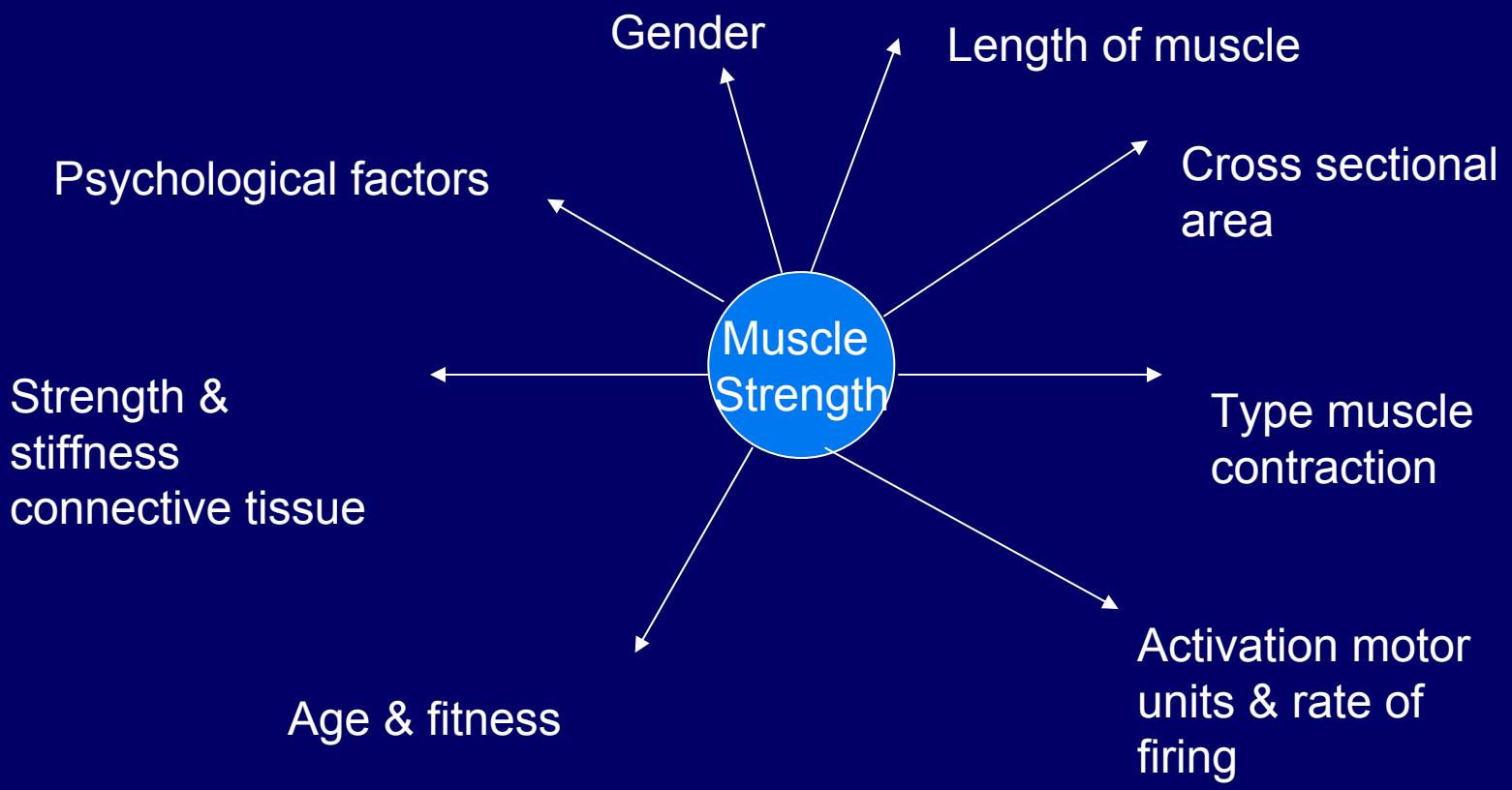
Overview

- Definitions
- Why we should measure strength
- Methods of measurement
- Which is best for which setting
- Examples from studies conducted previously
  - HRA – hand held dynamometry
  - UKA – muscle power
  - TKR – power & isometric strength

Strength

- The ability of a muscle, or group of muscles, to produce tension and a resulting force in one maximal effort, either dynamically or statically, in relation to the demands placed upon it.
  - Kisner & Colby 1990

Factors which determine muscle strength.



Muscle Power

- Power = the rate of working
- Work = Force x Distance moved by the force
- Power = Force x Distance / Time
- During a concentric contraction muscle is doing +ve work & so power is PRODUCED.
- During an eccentric contraction muscle is doing negative work & so power is ABSORBED

Types of Contraction

- Isotonic – muscle contracts against a constant load, with body segment moving against the load through range.
- Isometric – Muscle contracts against resistance sufficient to prevent movement
- Isokinetic – muscle contracts dynamically at a constant angular velocity.

Why measure strength?

- Standard goal of rehabilitation - ↑strength
- Close correlate to function
- Predictive value for overall outcome
- …….Because we always have !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Methods of measuring muscle strength

- Manual muscle testing
- Hand held dynamometry
- Isokinetic dynamometry
- Leg Extensor Power Rig
- Proxy measures – functional tasks

Manual muscle testing

- Oxford – MRC Scale

0 No contraction
1 Flicker or trace of contraction
2 Active throughout range – gravity counterbalanced
3 Active through range against gravity
4 Active through range against gravity & some resistance
5 Normal power

Pros & Cons

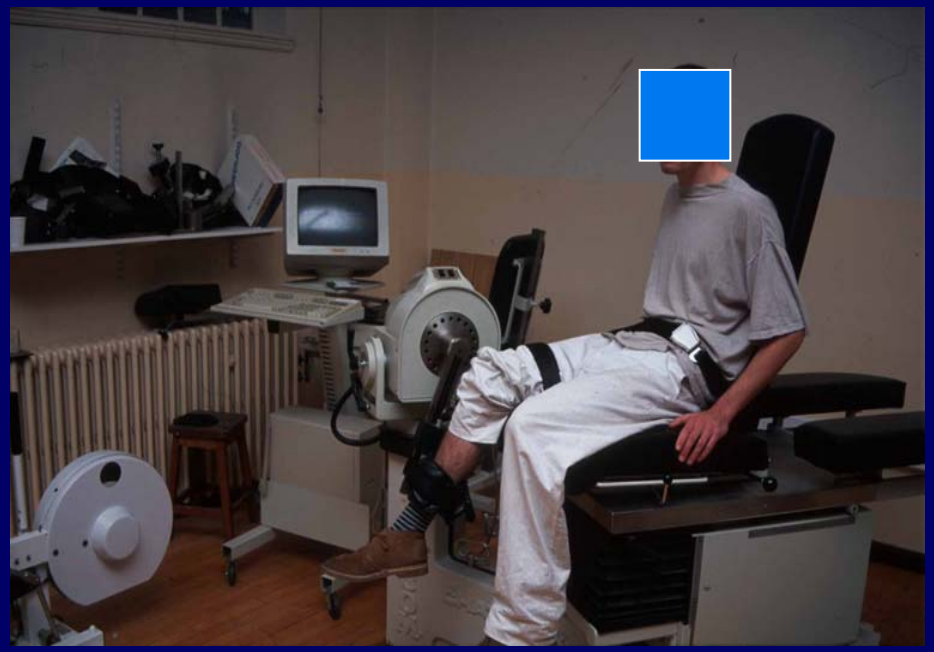
- No equipment needed
- Minimal training required
- Can be done anywhere
- Method used in 73% of articles on arthroplasty outcome
- Relies on subjective opinion of tester
- Poor inter tester reliability - % physios getting same grade 50-60% (Frese et al 1987)
- Poor validity cf other measures

Hand Held Dynamometer

Hand held dynamometry

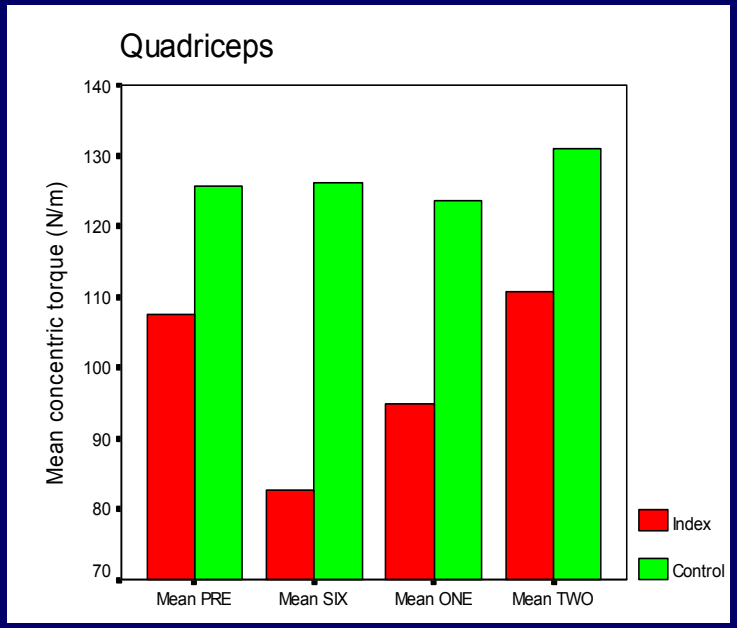
- Equipment easy to use
- Immediate output of force
- Portable
- Reliability depends on strict protocol
- Less accurate at high levels of strength
- Variable reports of reliability with muscle being tested.

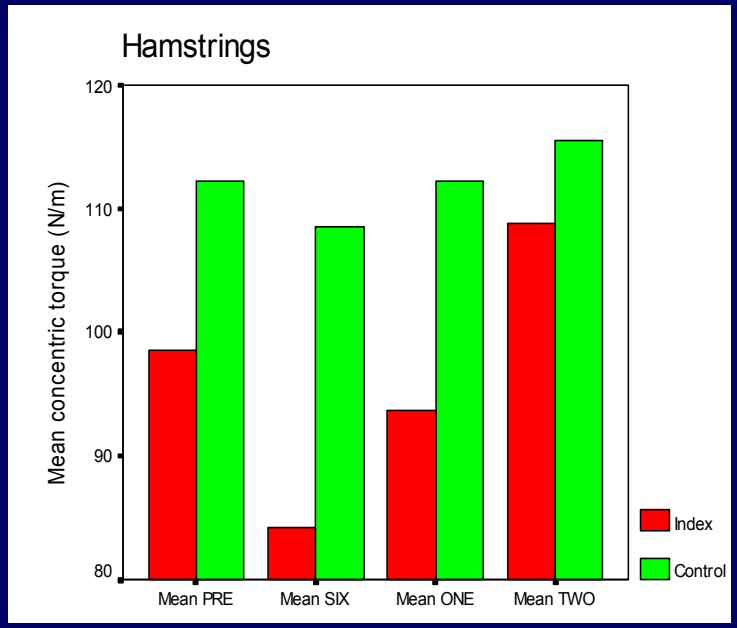
Isokinetic Dynamometer

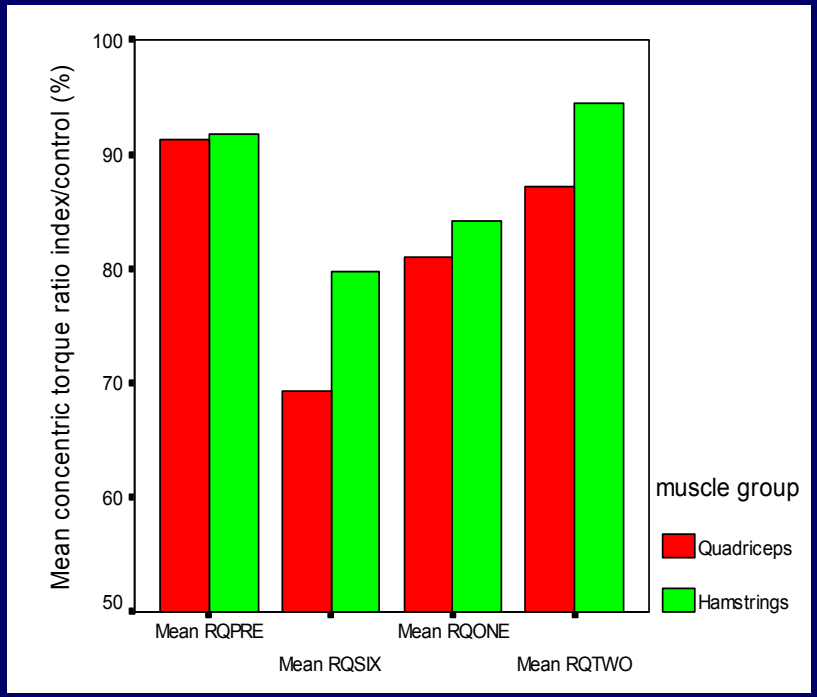


Isokinetic dynamometry

- Measure at set velocities
- Measure through set range
- Gives measure of both concentric & eccentric work
- Easy testing of agonist & antagonist
- Higher functioning patients
- Expensive
- Takes up lot of space
- Time consuming
- Training +++
- Learning curve for patients


Quadriceps
Mean concentric torque (N/m)
140
130
120
110
100
90
80
70
Mean PRE
Mean SIX
Mean ONE
Mean TWO
Index
Control

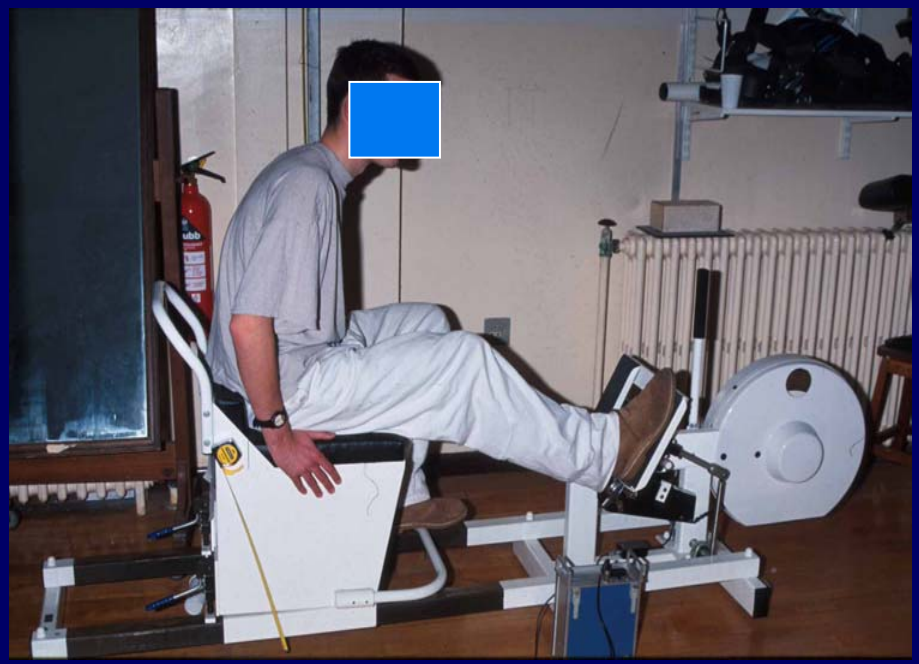

Hamstrings
Mean concentric torque (N/m)
120
110
100
90
80
Mean PRE
Mean SIX
Mean ONE
Mean TWO
Index
Control


Mean concentric torque ratio index/control (%)
100
90
80
70
60
50
Mean RQPRE
Mean RQSIX
Mean RQONE
Mean RQTWO
muscle group
Quadriceps
Hamstrings

Leg Extensor Power Rig

- Measures force – more functional
- Force along long axis of bone, not perpendicular
- Cheap
- Minimal training
- Patient friendly
- Instant output
- Space
- Threshold – not all patients can use
- Through range testing – can be painful
- Low to floor

Leg Extensor Power Rig



Proxy measures

- E.g. sit to stand,
  TUG, walking, stairs

Strength testing of hip flexor, extensor and abductor muscles following hip resurfacing arthroplasty using hand-held dynamometry : An investigation of inter-rater reliability

M Newman, K Duffy, J Sheehan, K Reilly, KL Barker.

Physiotherapy Research Unit, Nuffield Orthopaedic Centre NHS Trust, Oxford.

Background

- Audit of 125 Metal on metal (MoM) Hip Resurfacing Arthroplasty (HRSA) patients showed
  - The majority had good outcomes but deficits in hip strength persisted and were associated with greater pain and worse function.
- Reliable strength testing after HRSA needed to quantify impairments, plan rehabilitation and assess outcomes
- Manual testing has limitations, Hand Held Dynamometry (HHD) is a valid alternative with reliability established for varied conditions.

Reliability

- Reliability is specific to the population studied and HHD reliability is unknown in HRSA population.
- Inter-rater reliability concerned with equivalence of measures across 2 or more raters. If inter-rater reliability is established, it is reasonable to assume intra-rater reliability is as good

Aim

- To assess the inter-rater reliability of hip flexor, abductor and extensor muscle forces obtained with a HHD following hip resurfacing arthroplasty

Participants

- 24 adults attending a physiotherapy research clinic for review 1 year or more following MoM HRSA
- 8 women, 16 men, mean age 57, SD 7.6 years, 11 had right, 13 left hip resurfacings.
- Overall little pain, good function and activity levels:
  - Oxford Hip Score (12-60): mean 17.7, SD 7.8
  - UCLA activity scale (0-10): median 7, IQR 6-8, range 5-8.
  - 2 used walking stick
  - Hip Flexion ROM reduced: mean 95.6^0, SD 18.5 (40-120)

Methods

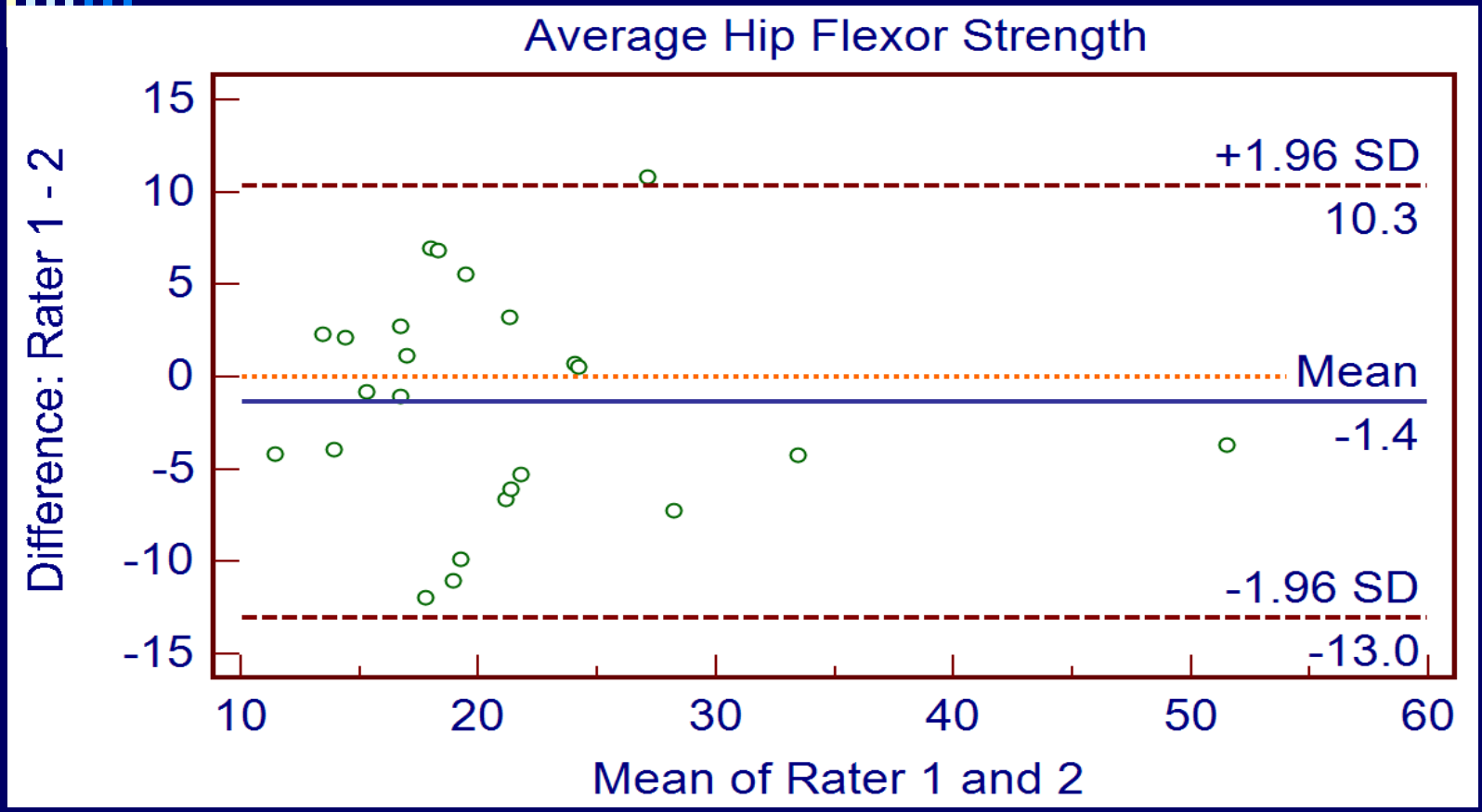
- Layfayette HHD
- 3 records hip flexors, abductors, extensors (kg)
- Isometric ‘Make’ test
  - Standard protocol
- Analysis
  - ICC, Bland & Altman
  - First and average of 3 measures compared

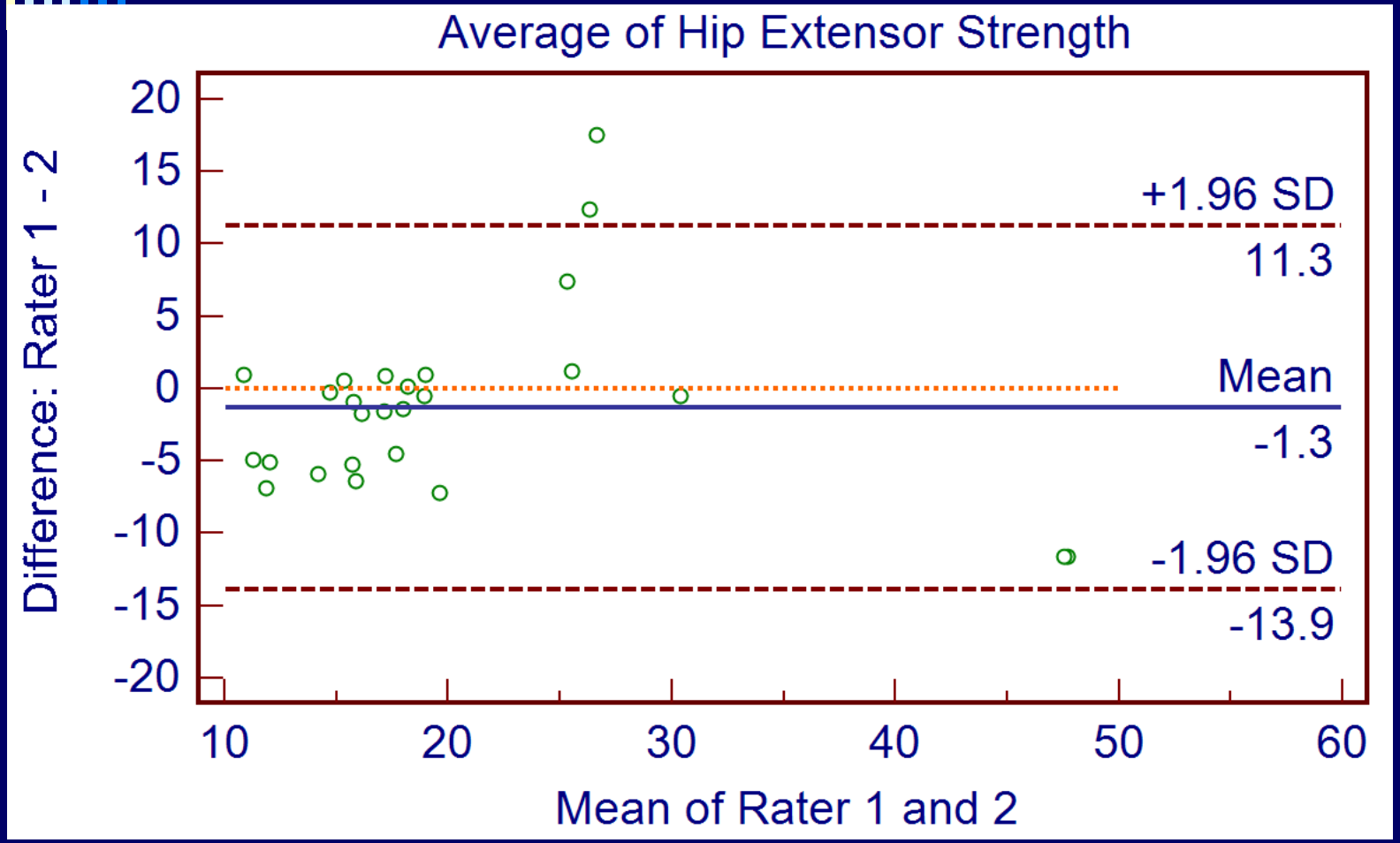
Hip Extension

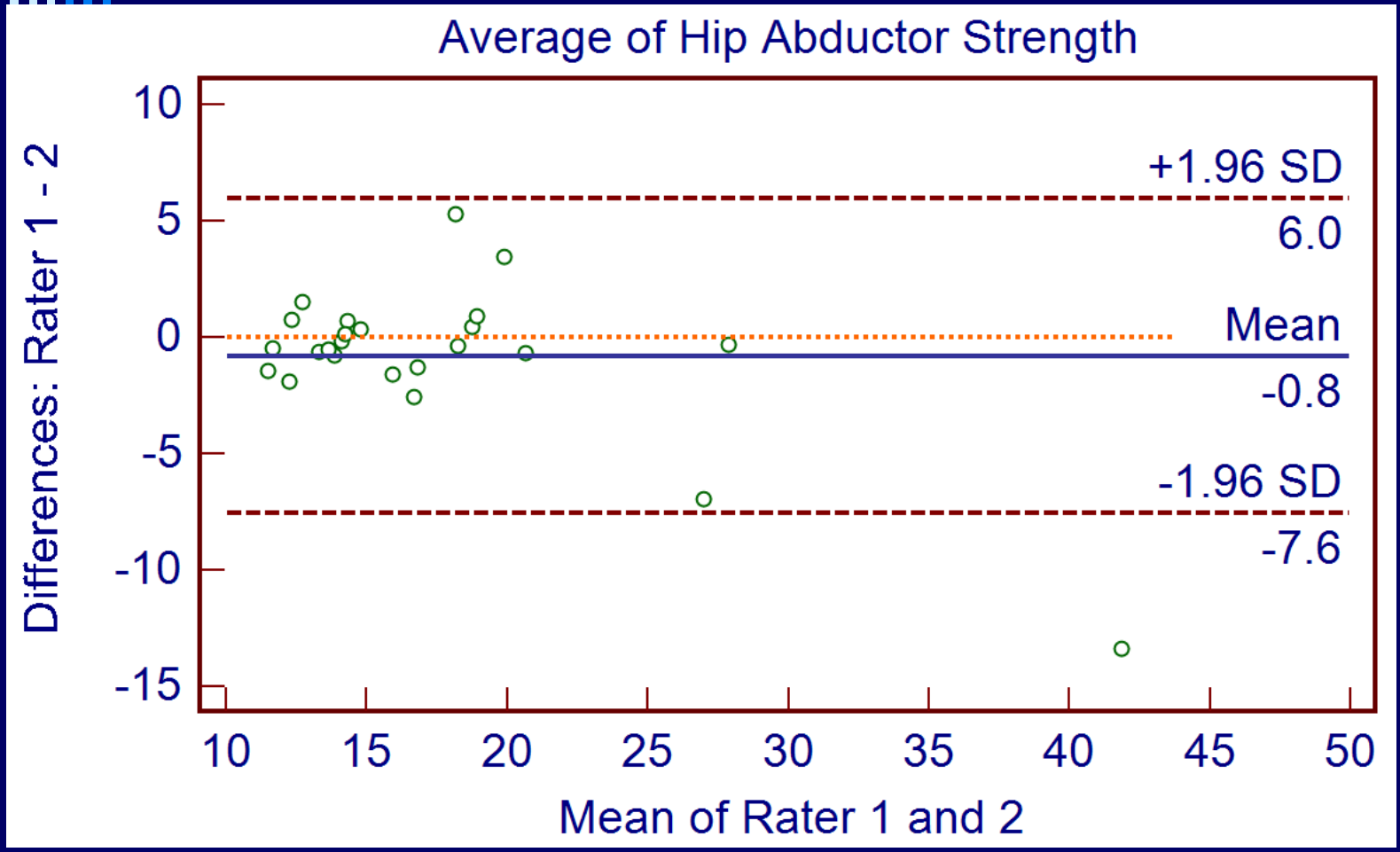
Results

Table 1: Strength and Intra-class Correlation Co-efficients

Muscle Group	Strength (kg) Mean, SD (Range)	ICC (95% Confidence Interval)
Hip Flexors Record 1 Average 3	 21.0, SD 8.2 (11.4 – 51.5) N/A	 0.75 (0.51 -0.88) 0.86 (0.69 -0.94)
Hip Abductors Record 1 Average 3	 17.5, SD 6.7 (11.5-41.8) N/A	 0.8 (0.59-0.91) 0.93 (0.85-0.97)
Hip Extensors Record 1 Average 3	 18.3, SD 7.4 (10.8-47.6) N/A	 0.78 (0.55 – 0.89) 0.90 (0.77-0.96)


Average Hip Flexor Strength
Difference: Rater 1 - 2
15
10
5
0
-5
-10
-15
+1.96 SD
10.3
Mean
-1.4
-1.96 SD
-13.0
10
20
30
40
50
60
Mean of Rater 1 and 2


Average of Hip Extensor Strength
Difference: Rater 1 - 2
20
15
10
5
0
-5
-10
-15
-20
+1.96 SD
11.3
Mean
-1.3
-1.96 SD
-13.9
10
20
30
40
50
60
Mean of Rater 1 and 2


Average of Hip Abductor Strength
Differences: Rater 1 - 2
10
5
0
-5
-10
-15
+1.96 SD
6.0
Mean
-0.8
-1.96 SD
-7.6
10
15
20
25
30
35
40
45
50
Mean of Rater 1 and 2

Discussion

- Measuring strength with a HHD using a ‘make test’ and tailored test position was feasible for patients following hip arthroplasty surgery.
- Overall HHD appears a reliable method of assessing hip flexor, abductor and extensor strength
- Using the mean of 3 measures, the same HHD, a ‘make test’ and standard protocol to reduce sources of error and improve reliability is recommended.

Muscle Power and Function after Uni-compartmental Knee Replacement

Barker KL, Jenkins CM, Pandit H, Jones R Murray DW.

Nuffield Orthopaedic Centre

Background

- Uni-compartmental knee replacement (UKR) is a commonly performed procedure, suitable for one in four patients requiring knee replacement.
- Recovery and return of function is quicker than with total knee replacement, but little information is known about the recovery of muscle power.
- We prospectively studied a cohort of 44 patients undergoing medial UKR to document their functional recovery and leg extensor power.

Leg Extensor Power

- 2 warm ups, then 5 maximal pushes
- Encouraged to push as hard & fast as could
- 15 second rest between each test

Data

- Body weight was recorded using a set of calibrated bathroom scales.
- Measures of LEP were summarised as relative power i.e. absolute power divided by body weight, as this index has greater functional relevance and allows comparison between patients of different weights as well as comparison with other studies.

Functional Measures

- Oxford Knee Score
- Tegner

- Both self administered pre-operatively & at one year

Results

- Patients had a mean age of 63 years (SD 11, range 43 - 83). There were 21 males and 23 females.
- The status of the contra-lateral limb was symptomatic in 21 patients, asymptomatic in 12 patients and 11 had previously received a joint replacement on the contra-lateral limb.

Results

	Pre-op	One Year	Change	Significance
LEP op leg W/Kg Mean, SD.	0.85 (0.35)	1.38 (.46)	0.53 (.46)	P<0.001
LEP cont leg W/Kg Mean, SD.	1.25 (.44)	1.42 (.58)	0.16 (.45)	P<0.001
OKS Mean, SD.	22.8 (6.3)	38.7 (8.1)	15.9 (9.8)	P<0.001
Tegner Mean, SD.	2.2 (.78)	3 (0.8)	0.81 (.78)	P<0.022

Discussion

- In the majority of the participants pre-operatively, the affected leg was weaker than the non-operated leg.
- At one year there was no statistically significant difference in LEP between the operated and non-operated limbs, with a minimal difference of 1.38 compared with 1.41 W/Kg.

- Compared to healthy age matched normative values the UKR LEP values at one year after surgery were significantly decreased.
- Skelton et al cite a normal LEP value as 2.8 W/Kg for a healthy man of 65-69 years and 2 W/Kg for a healthy 65-69 year old women.
- The value we found for our UKR group of 1.38W/Kg for the replaced limb equates to 69% of that of a 65-69 year old woman or the normative value of a healthy 80 year old woman.

- Lamb et al reported that LEP was the main preoperative factor associated with recovery of mobility after TKR.
- The substantial deficit in muscle power we observed should be considered when devising rehabilitation programmes following UKR.
- It is important that patients have sufficient muscle power to generate effective force to maintain functional mobility and prevent falling.

Leg extensor power & quadriceps strength: repeatability in patients with OA knees

Sunita Robertson

Physiotherapy Research Unit

Nuffield Orthopaedic Centre

Background

- Accurate assessment of the outcome of surgery & rehabilitation needed.
- Repeatability of isometric and power measures not widely established in people with severe OA knee, where measurement is challenged by pain & ligamentous instability.

Aim

- To assess the repeatability of isometric dynamometry & leg extensor power

Participants

- Patients on waiting list for elective TKR.
- Able to attend on 2 occasions one week apart.

Method

- Isometric quadriceps force (IQF) using Kin-Com dynamometer.
- Patient seated upright
- Measures taken at 50° and 25° knee flexion.
- Standardised instructions

Leg Extensor Power Rig

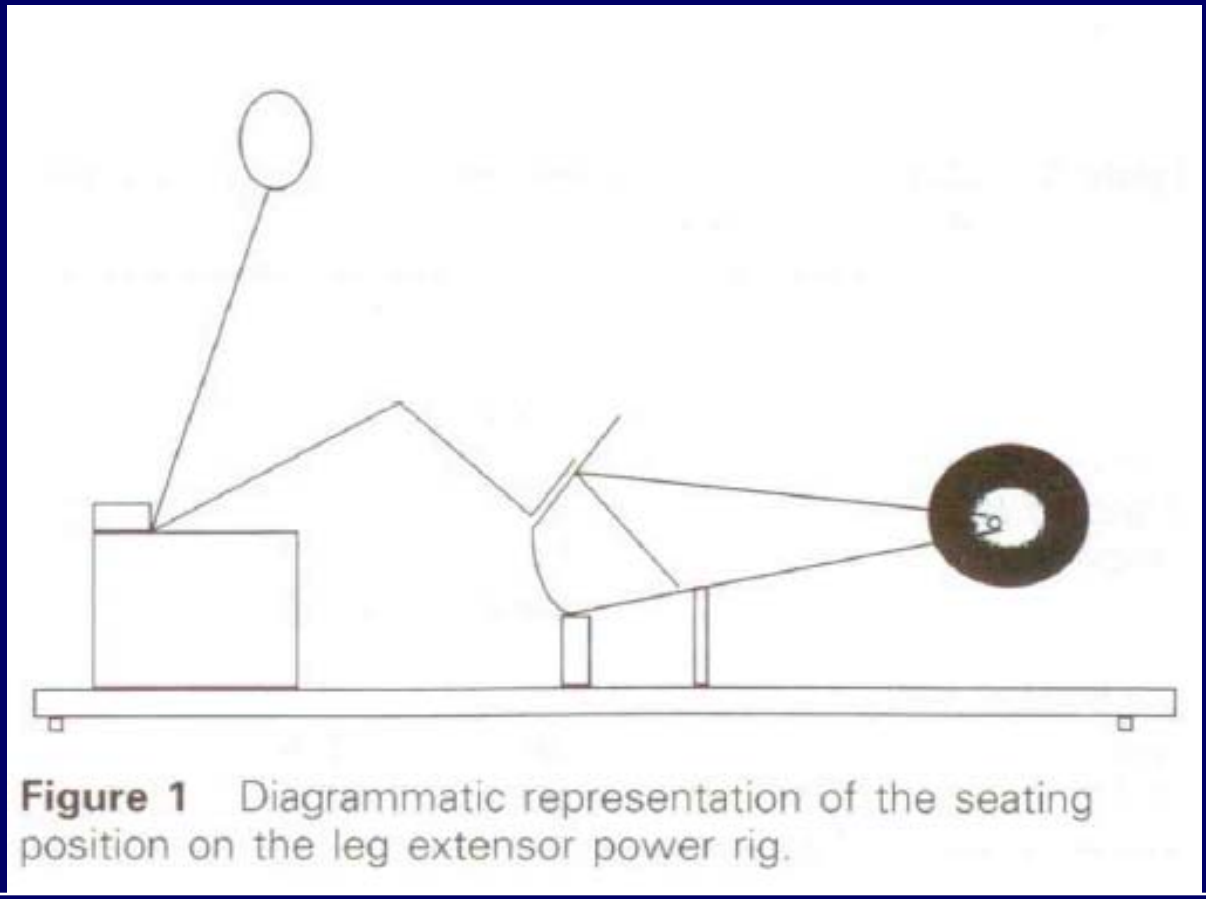


Figure 1 Diagrammatic representation of the seating position on the leg extensor power rig.

Data Collection

- Unaffected leg tested first
- IQF recorded in Newtons
- Best result at each angle ie mean force during 5 second contraction recorded.
- LEP highest value from maximum of 10 attempts.
- Output divided by body weight to standardise.

Data Analysis

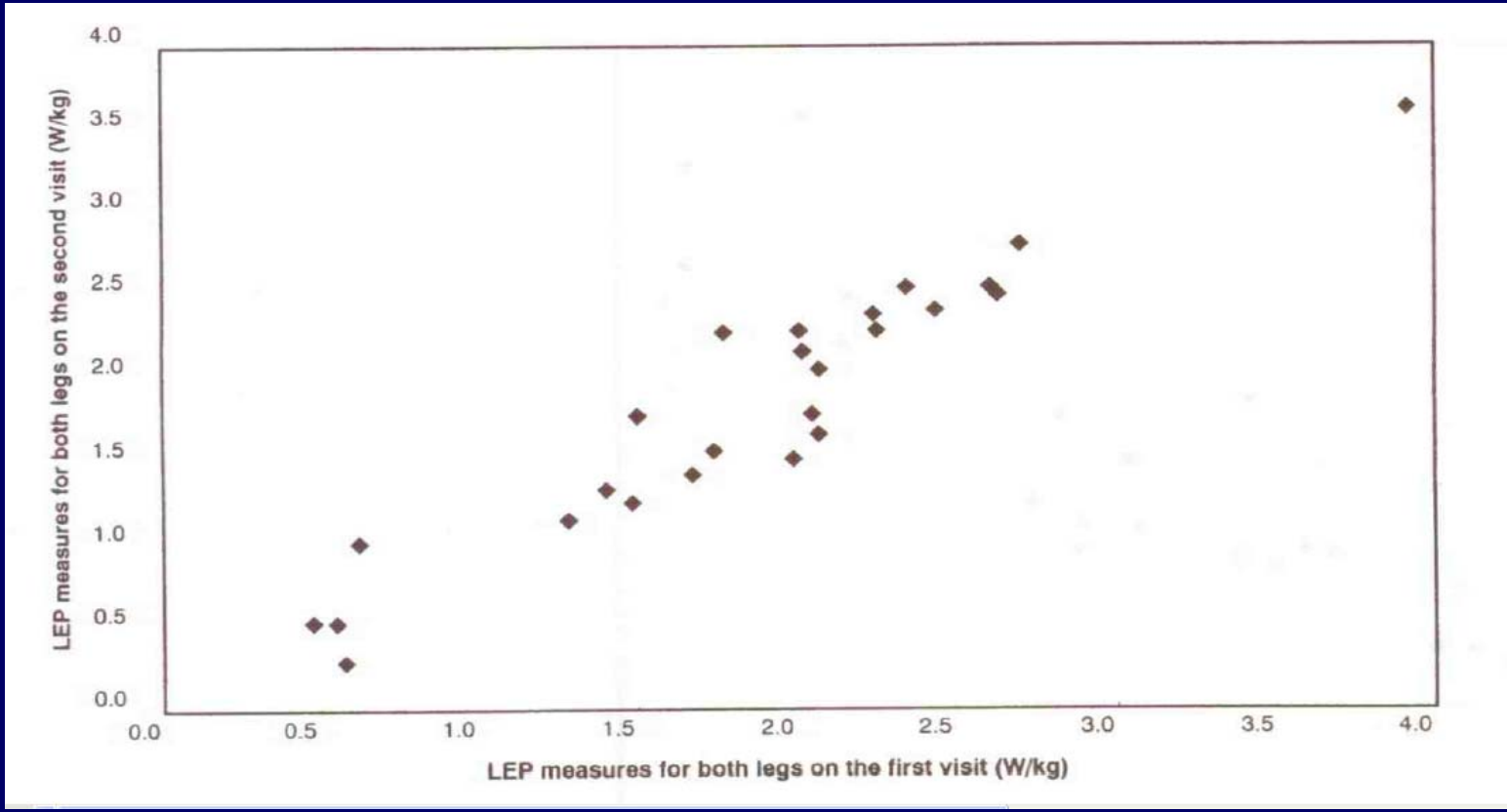
- Paired t test to assess any statistically significant difference between test 1&2.
- Bland & Altman plots for repeatability
- Coefficient of variation (CV) to assess the amount of variation in the data.

Results

Table 2 Changes in measures for both legs for all subjects: statistical significance of the changes observed and measures of repeatability

	LEP (W/kg) (n = 26)	25° IQF (N/kg) (n = 25)	50° IQF (N/kg) (n = 25)
Mean difference	0.03	0.45	−0.21
Standard deviation (SD)	0.24	1.42	1.58
95% CI†	−0.06 to +0.12	−0.18 to +0.96	−0.78 to +0.36
cv‡	9%	19%	13%
t-test (p-value)	t = 0.53 (p = 0.60)	t = 1.38 (p = 0.18)	t = 0.21 (p = 0.84)
	Bland & Altman method for repeatability[10]		
Error SD = s*	0.17	1.03	1.13
95% of the differences will be expected to lie below•	±0.47	±2.86	±3.13

†95% confidence intervals for the true differences.


LEP measures for both legs on the second visit (W/kg)
LEP measures for both legs on the first visit (W/kg)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

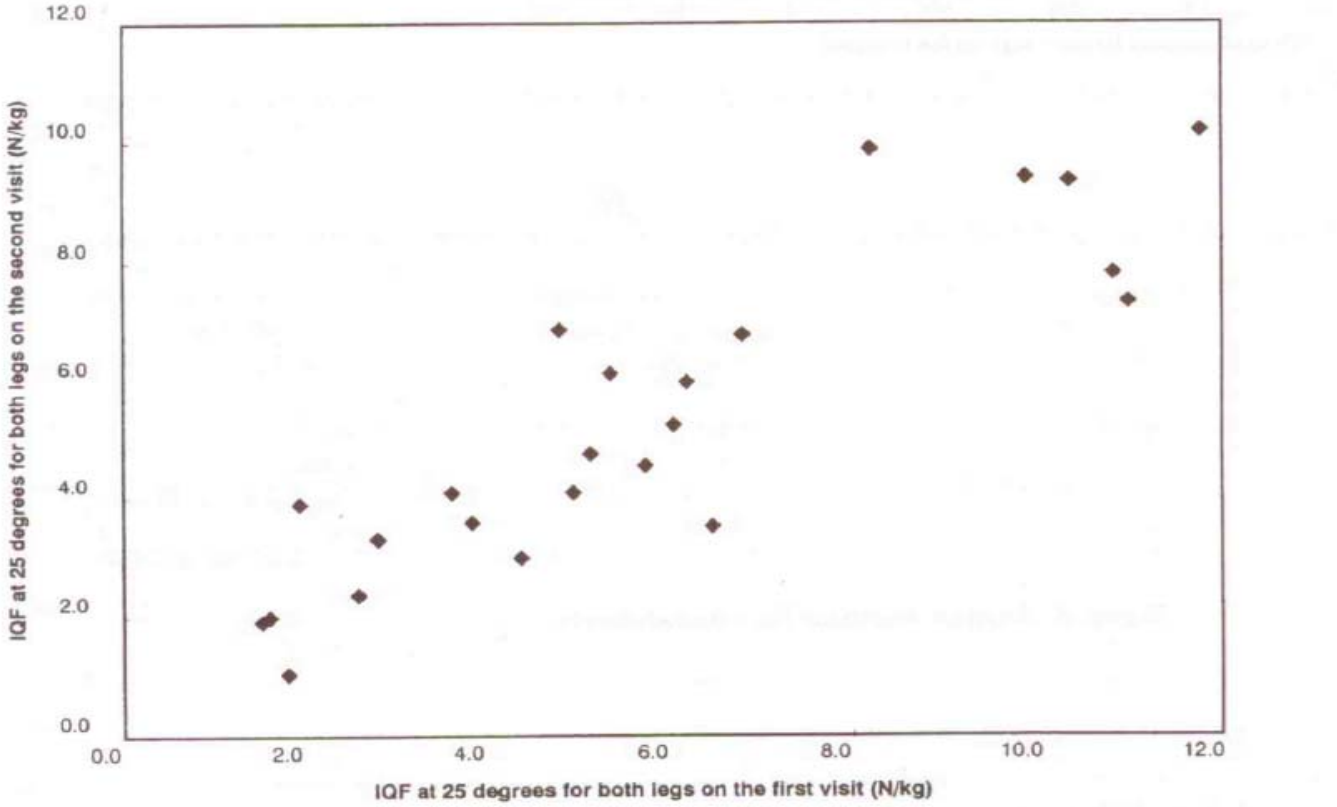


Figure 3 Repeat 25° IQF measures for both legs (summed) are plotted with the first test vers

Results

- Repeatability greatest for LEP
- Then IQF at 50° & 25°.
- Precision for estimate for mean difference best for LEP.
- No significant difference to pain scores during testing

Conclusions

- LEP & IQF both had acceptable reliability in this population.
- LEP rig, quicker & simpler to use in clinical setting.
- Used to predict outcome in further study

Which method to use with arthroplasty patients?

- In clinic – HHD or proxy measure
- In research / cohort studies in field – HHD
- Hospital based research – ltd sites – LEP
- Higher function or complex research – isokinetic dynamometry

Thank You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Not running is bad for everything else!"