Effect of Eccentric Hamstring Strengthening on Prevention of Hamstring Muscle Strains: An Evidence Based Review

Patrick Rugo, DPTc
UCSF/SFSU Graduate Program in Physical Therapy

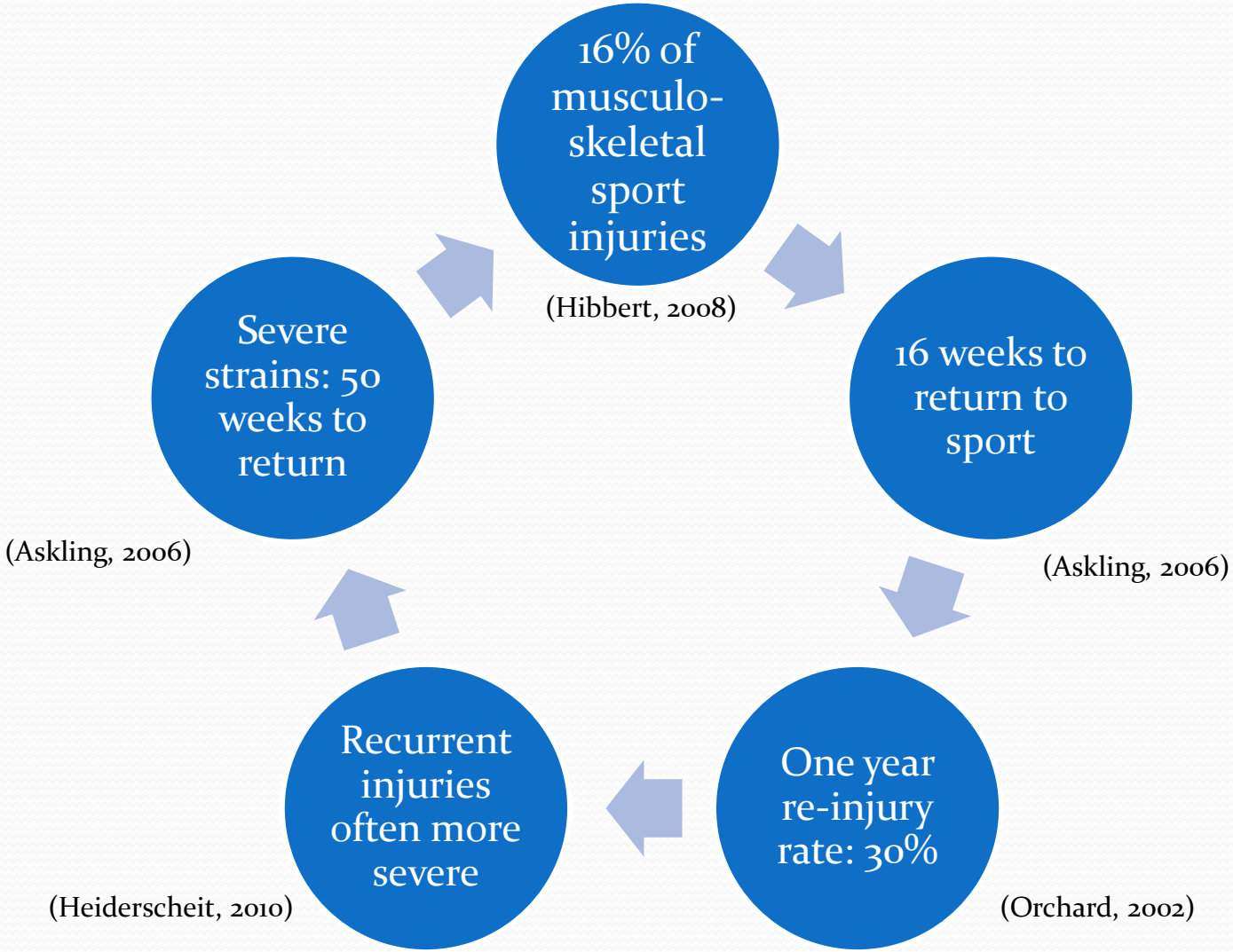
UCSF
University of California
San Francisco

SAN FRANCISCO STATE UNIVERSITY

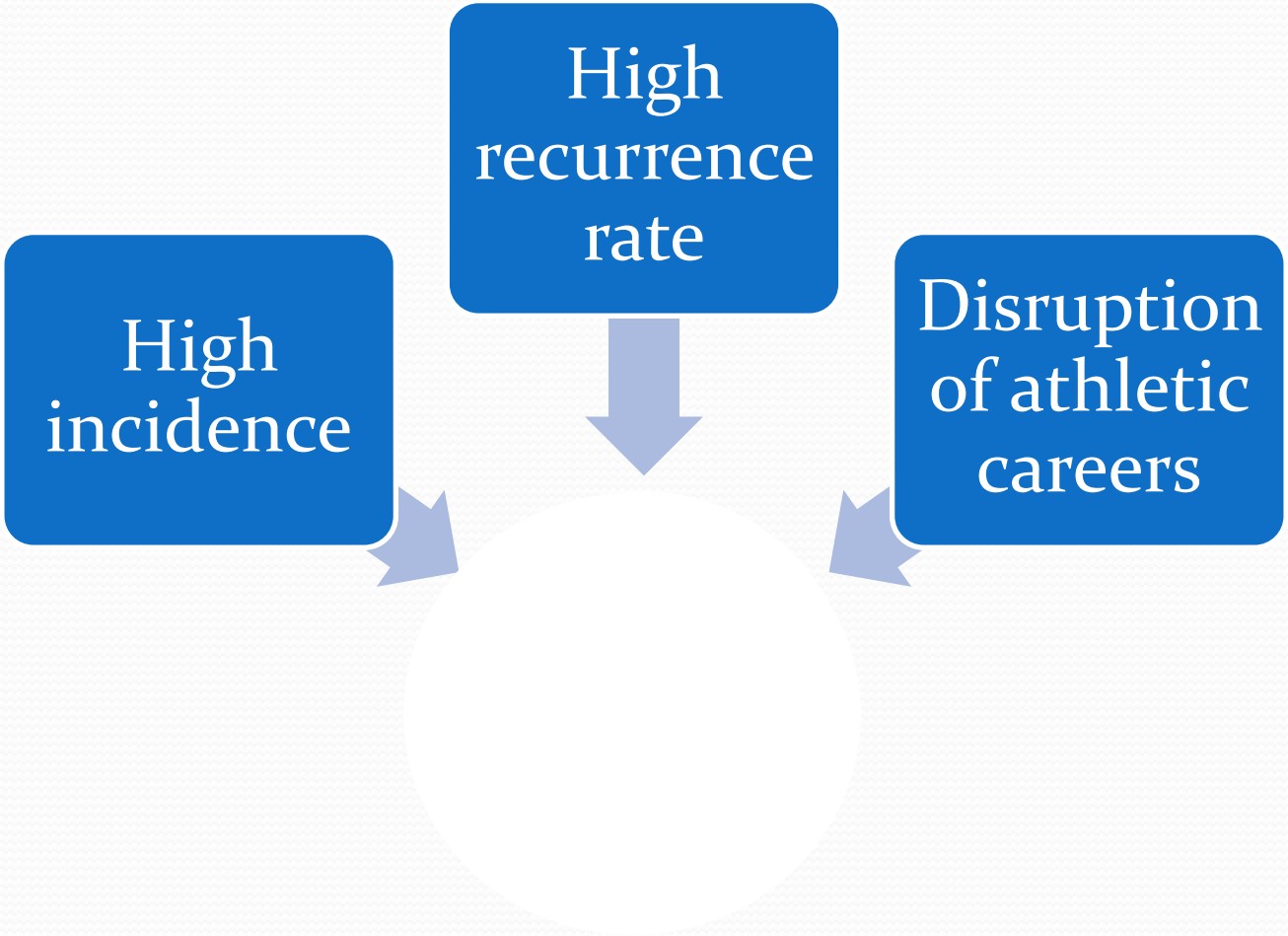
My Personal Experience

- Sprinter: 100, 200, 400, 4 x 100 and 4 x 400 meter races
- I suffered a hamstring strain 2003
  - Re-injured 2004, 2010
  - Stopped competitive track 2003

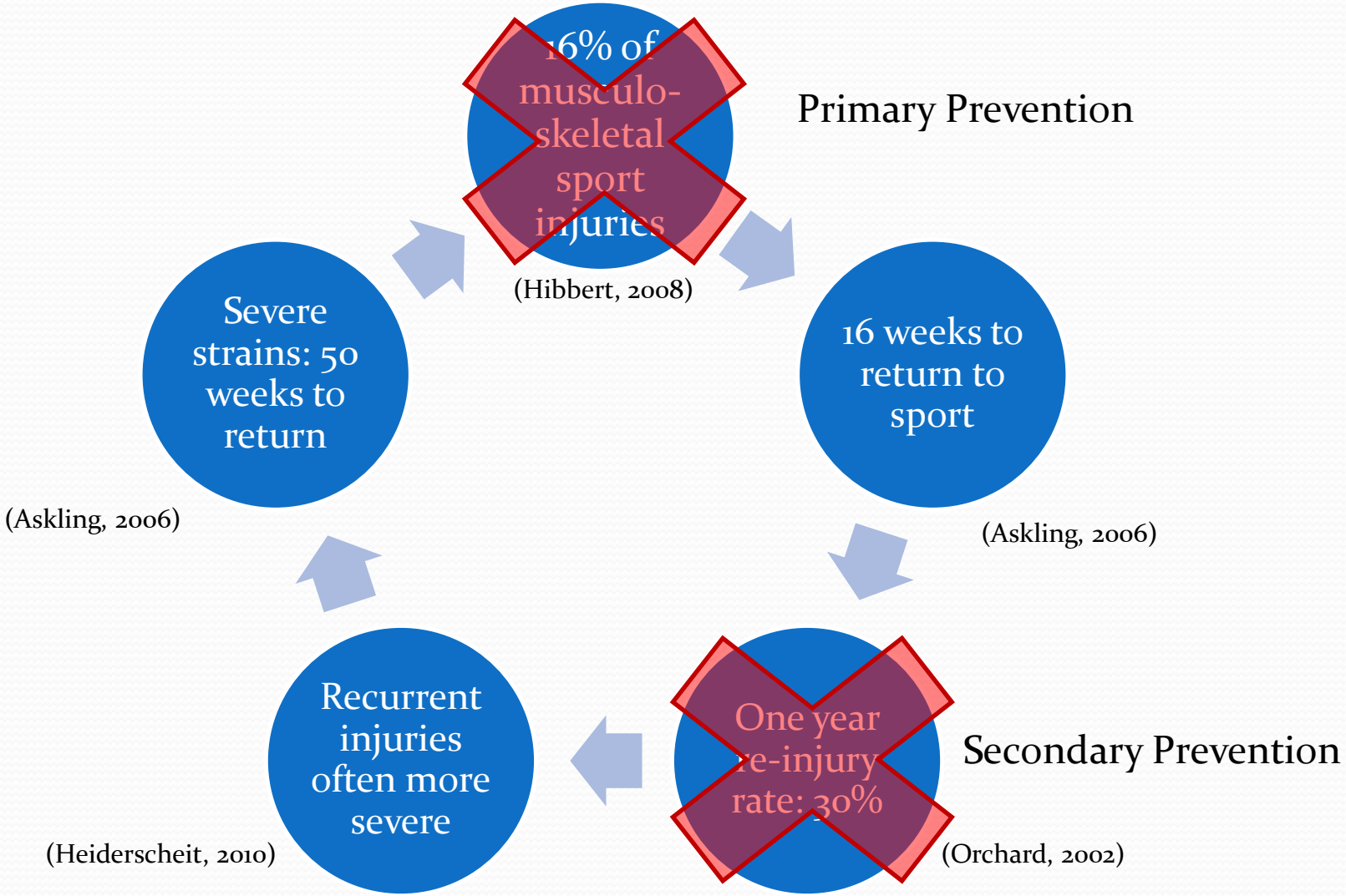
Significance



Clinical Problem



PT Role


16% of musculo-skeletal sport injuries
(Hibbert, 2008)
Primary Prevention
16 weeks to return to sport
(Askling, 2006)
One year re-injury rate: 30%
(Orchard, 2002)
Secondary Prevention
Recurrent injuries often more severe
(Heiderscheit, 2010)
Severe strains: 50 weeks to return
(Askling, 2006)

Relevance to PT

- Need optimal intervention for prevention of hamstring strains for sprinting athletes
  - Primary prevention
  - Secondary prevention/rehabilitation
- Eccentric hamstring strengthening may be effective in preventing hamstring strains (Hibbert, 2008)

How Can Prevention be Measured?

- Control event rate (CER): (# strains)/(N control)
- Experimental event rate (EER): (# strains)/(N experimental)
- Relative risk (RR): EER/CER
- Number needed to treat (NNT): 1/(CER-EER)

What is a Muscle Strain?

- Disruption of muscle tissue
  - High velocity, high force contractions
  - Intramuscular tendon, aponeurosis, and adjacent muscle fibers
  - Hamstrings proximal > distal
- Severity
  - Grade I/Mild: Pain but no loss of strength
  - Grade II/Moderate: Loss of strength and pain with resisted contraction
  - Grade III/Severe: Rupture of muscle, complete loss of strength and function

(Heiderscheidt, 2010)

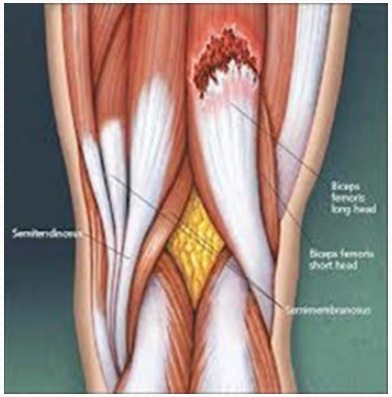
What is Eccentric Exercise?

- Utilizes eccentric muscle contraction
  - Lengthening contraction
  - Able to produce more force with less energy and oxygen consumption than concentric (Lorenz, 2011)
- Hamstring specific exercises
  - Nordic Hamstring Lowers
  - Yoyo™ Flywheel

Theoretical Construct

- Mechanism of injury
  - Terminal swing phase during sprinting
    - Just prior to foot contact (Schache, 2009)
    - Hamstrings near maximal length
    - Hamstrings eccentrically contracting
      - Decelerate leg to prepare for initial contact
      - EMG indicates active eccentric contraction (Jonhagen et al., 1996)

- Elongated over 2 joints
- Minimal sarcomere overlap
- Rapid, forceful contraction



Associated Risk Factors

Increased Age

- Relative risk (RR) ↑ 1.78 per year over 23 (Freckleton, 2012)

Decreased Hip Flexion AROM

- RR ↑ 1.29 for each degree limitation from normal

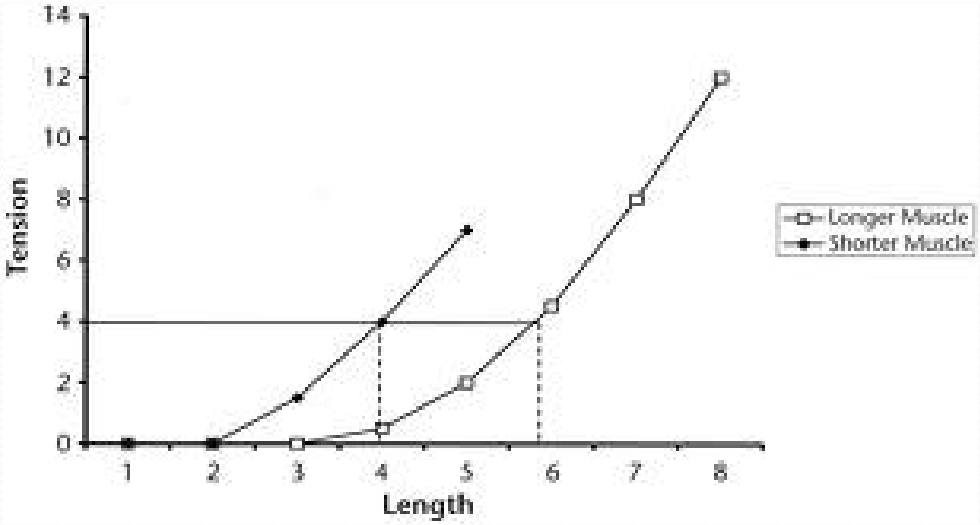
(Henderson, 2010)

Decreased Eccentric Strength

- Side-to-side eccentric strength
- Ratio of ≤ 0.85 = RR 3.88 (Fousekis, 2011)

Theoretical Construct

- Eccentric hamstring strengthening (Brockett et al., 2001)
  - Increases eccentric contractile strength
  - Increases functional muscle length
    - Adjusts length-tension curve
      - Peak force development at longer muscle lengths



Theoretical Construct: Overview

If hamstring strains are caused by

↓ eccentric strength | ↓ hamstring length

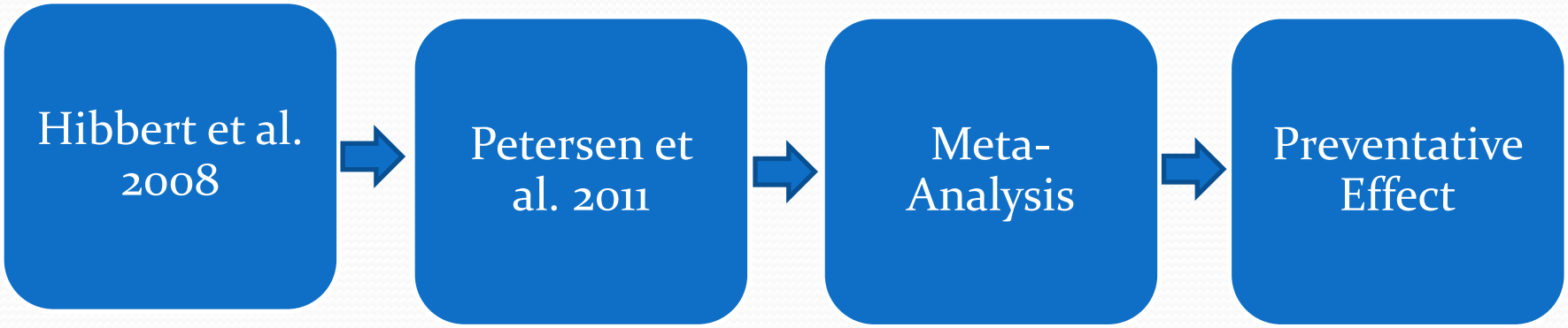
And eccentric hamstring strengthening can

↑ eccentric strength | ↑ hamstring length

Then eccentric hamstring strengthening may be able to

↓ RR of hamstring strain

Gap in Current Literature



- Systematic Review
- Studies suggest possible preventative effect
- Limited by heterogeneity, poor methodological rigor
- **No meta-analysis performed**

- RCT level 1B
- Large N
- Eccentric vs controls
- No confounding exercises

- Limit studies for homogeneity
- Eccentric vs controls
- Graded effect size
- RR hamstring strain

Primary Question

- Does eccentric hamstring strengthening reduce the risk of hamstring strain amongst high level adult male sprinting athletes?

- Foreground Question
- P: High level adult male sprinting athletes
- I: Eccentric hamstring strengthening
- C: Control/normal sport training
- O: Hamstring strain occurrence/injury rate

Hypotheses

- **Null hypothesis**: There will be **no significant difference** between athletes who perform eccentric hamstring strengthening with standard sport training and those who perform standard sport training alone in the rate of hamstring strain injury.
- **Alternative Hypothesis**: Athletes who perform eccentric hamstring strengthening with standard sport training will have a **significantly lower rate of hamstring strain** injury than those who perform standard sport training alone.

Expected Findings

- Studies
  - 3 to 8
  - Mixed evidence: Level 1 – 4

- Answer to primary question
  - Hamstring strain risk is significantly reduced by eccentric hamstring strengthening

Methods: Search Procedures

- Inclusion Criteria
  - Primary intervention: eccentric hamstring strengthening
  - Control group
  - English language
  - Outcome measure: hamstring strain
  - Population: men ages 18 – 40, participating in soccer/track

- Exclusion Criteria
  - Full text unavailable
  - Concentric/isokinetic strengthening as part of primary intervention

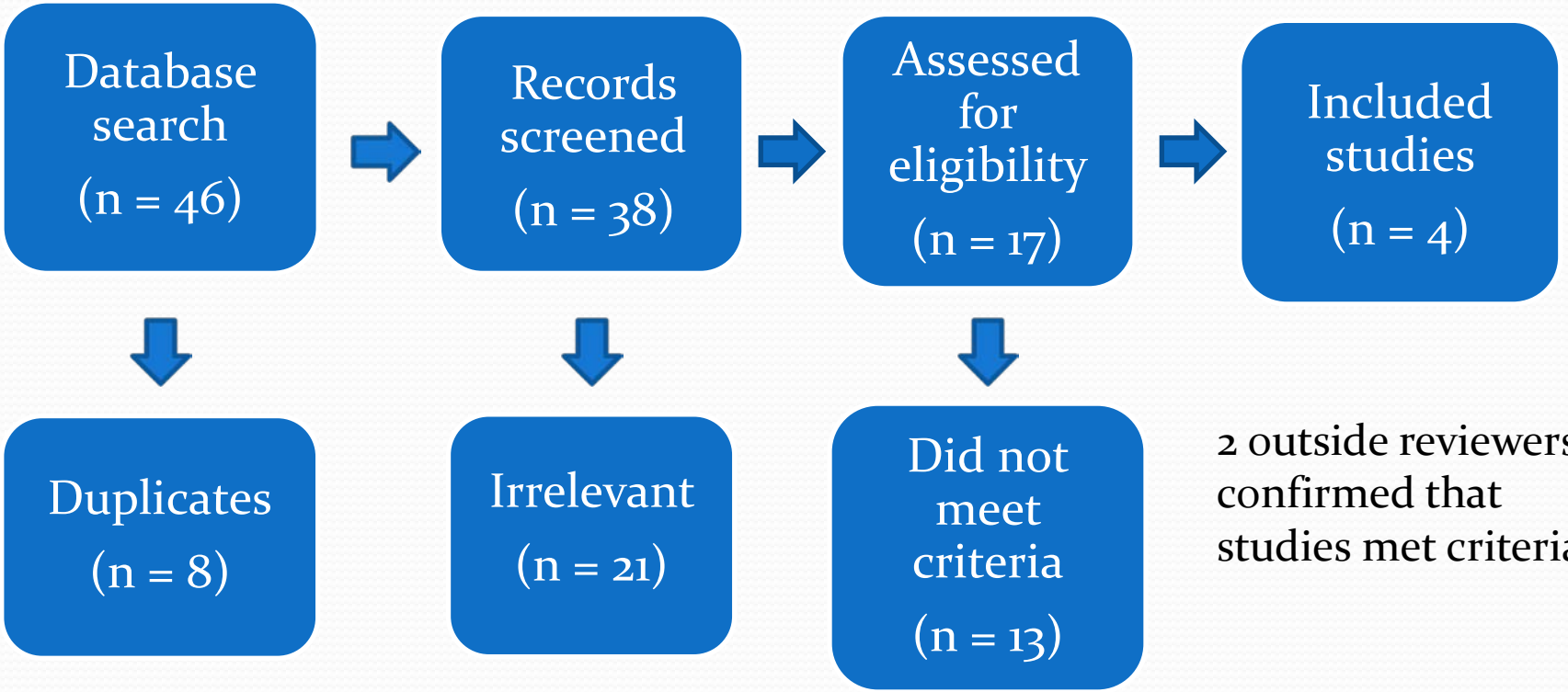
Methods: Search Procedures

- Databases: Pubmed, Cochrane Library
- Search Terms
  - hamstring AND (injury OR strain) AND eccentric AND prevention
  - hamstring strain
  - eccentric
  - prevention

Statistics

- Recorded: EER, CER, RR, NNT
- Calculated
  - If RR not given use EER and CER for RR
  - 95% confidence interval (95% CI) for RR: use ln(RR), standard error (SE) of ln(RR), 95% CI for ln(RR), finally convert back using exponent e (e^{lnRR})
  - Individual studies weighted by inverse variance
  - Heterogeneity statistic Q with *P* value
    - $P > .05$ = fixed effect model
    - $P < .05$ = random effects model
  - Combined RR and 95% CI

Results: PRISMA diagram



2 outside reviewers confirmed that studies met criteria

Last search: 2/2/2013

Description of Studies

Study	Design	Level of Evidence	Subjects	Control N	Exp N
Arnason et al.	PC	4	Icelandic and Norwegian pro soccer players	62,903 hours	63,636 hours
Askling et al.	RCT	2b	Swedish pro soccer players	15	15
Gabbe et al.	RCT	2b	Australian semi-pro soccer players	114	106
Petersen et al.	RCT	1b	Danish pro soccer players	461	481

Abbreviations: PC = prospective cohort, RCT = randomized control trial, N = number of subjects, Exp = experimental group

Description of Studies

Study	Intervention	Protocol
Arnason et al.	Nordic	Week / Sessions/Week / Sets and Reps 1 / 1 / 2 x 5 2 / 2 / 2 x 6 3 / 3 / 3 x 6-8 4 / 3 / 3 x 8-10 5-10 / 3 / 3 x 12/10/8 10+ / 1 / 3 x 12/10/8
Askling et al.	Yoyo™ flywheel	10 weeks, 16 sessions Weeks 1-4: Every 5th day Weeks 5-10: Every 4th day Session: 4 sets of 8 reps with 1 minute breaks between sets
Gabbe et al.	Nordic	12 weeks, 5 sessions Session: 12 sets of 6 reps with 10 second rest between reps and 2-3 minute rest between sets
Petersen et al.	Nordic	Same as Arnason et al.

Abbreviations: Reps = repetitions

Description of Studies

Study	Hamstring Strains Exp/Control	RR (95% CI)	NNT
Arnason et al.	14/39	.35 (.19-.64)	-
Askling et al.	3/10	-	-
Gabbe et al.	18 total	1.20 (.66-2.16)	-
Gabbe 2+ Sessions	-	0.30 (.10-1.40)	-
Petersen et al.	15/52	.30 (.18-.49)	13
Petersen Primary	12/32	.41 (.18-.93)	25
Petersen Recurrent	3/20	.14 (.04-.51)	3

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Intention to treat

Description of Studies

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Only subjects who participated in 2 or more sessions

Description of Studies

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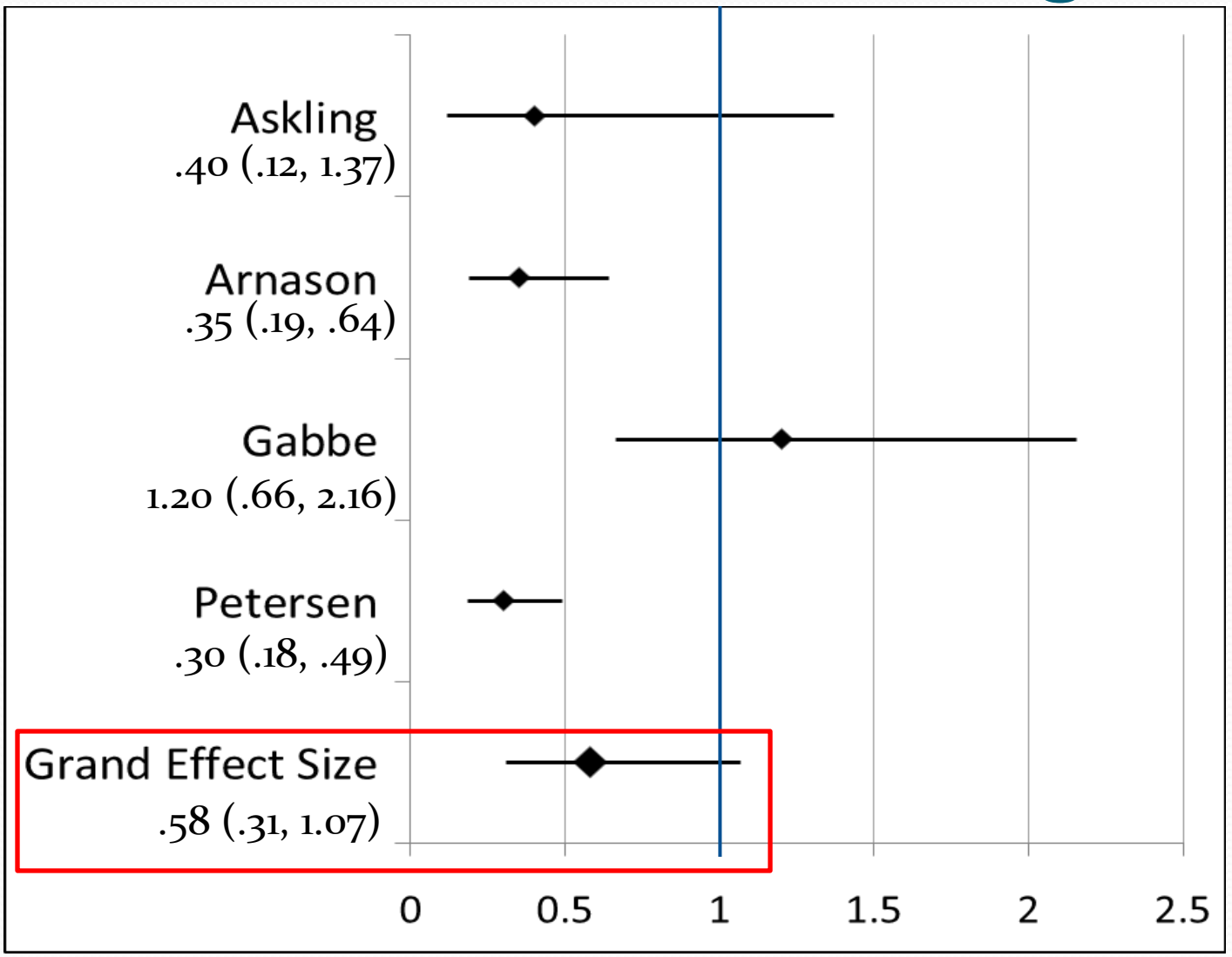
Data Analysis

- Q significant ($P = 0.003 < 0.05$)
  - Random effects model
- RR effect size
  - Experimental/control
  - RR < 1 favors experimental
  - RR > 1 favors control
  - 95% CI crosses 1 = not statistically significant
  - Trend = grand effect size + SE < 1

Forest Plot: RR of Hamstring Strain

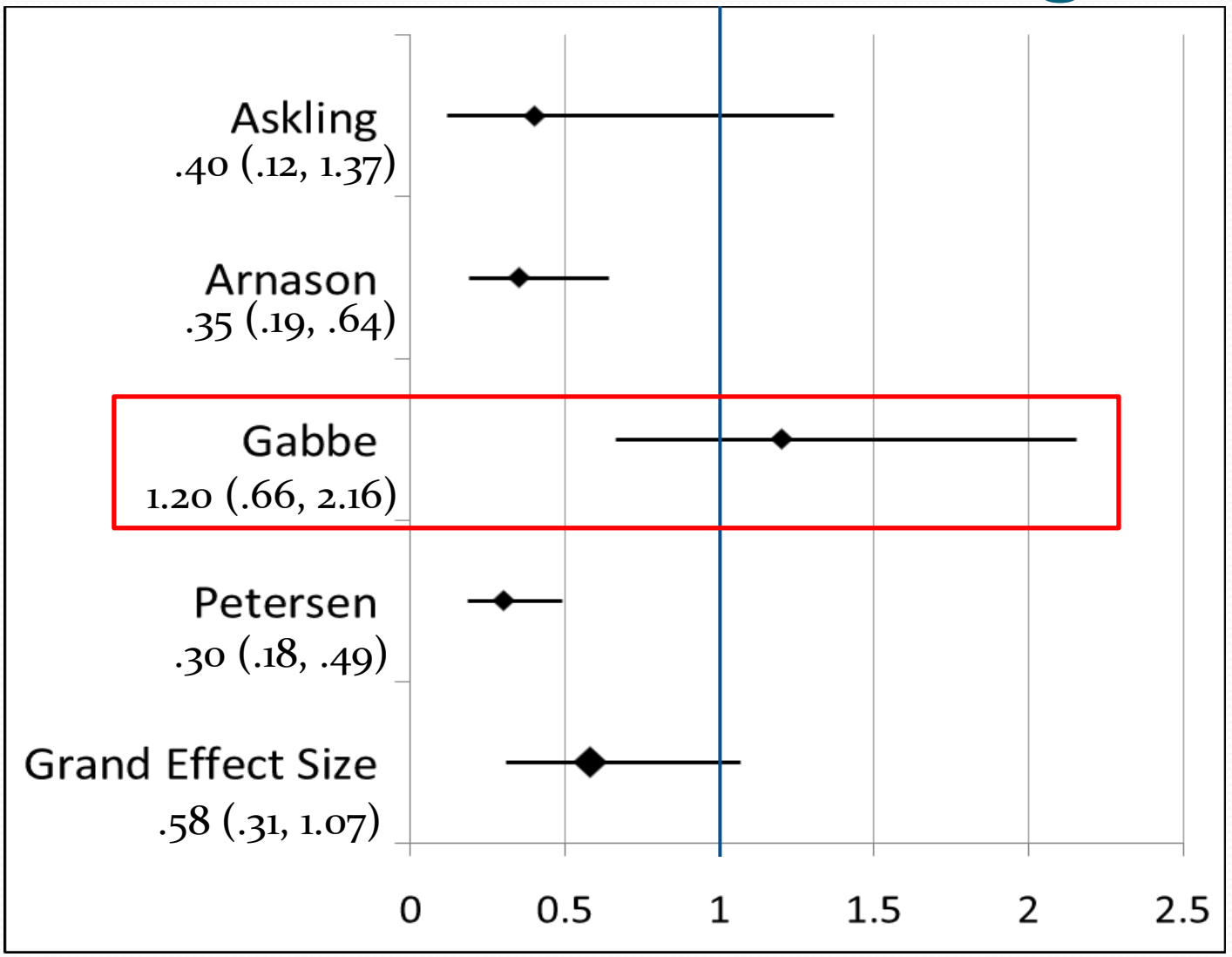


Grand Effect Size

- RR (95% CI) = .58 (.31, 1.07)
  - Crosses 1 = not statistically significant
- RR + SE = .58 + .33 = .91
  - .91 < 1 = trend in favor of fewer hamstring strains

Significant effect hidden in data?

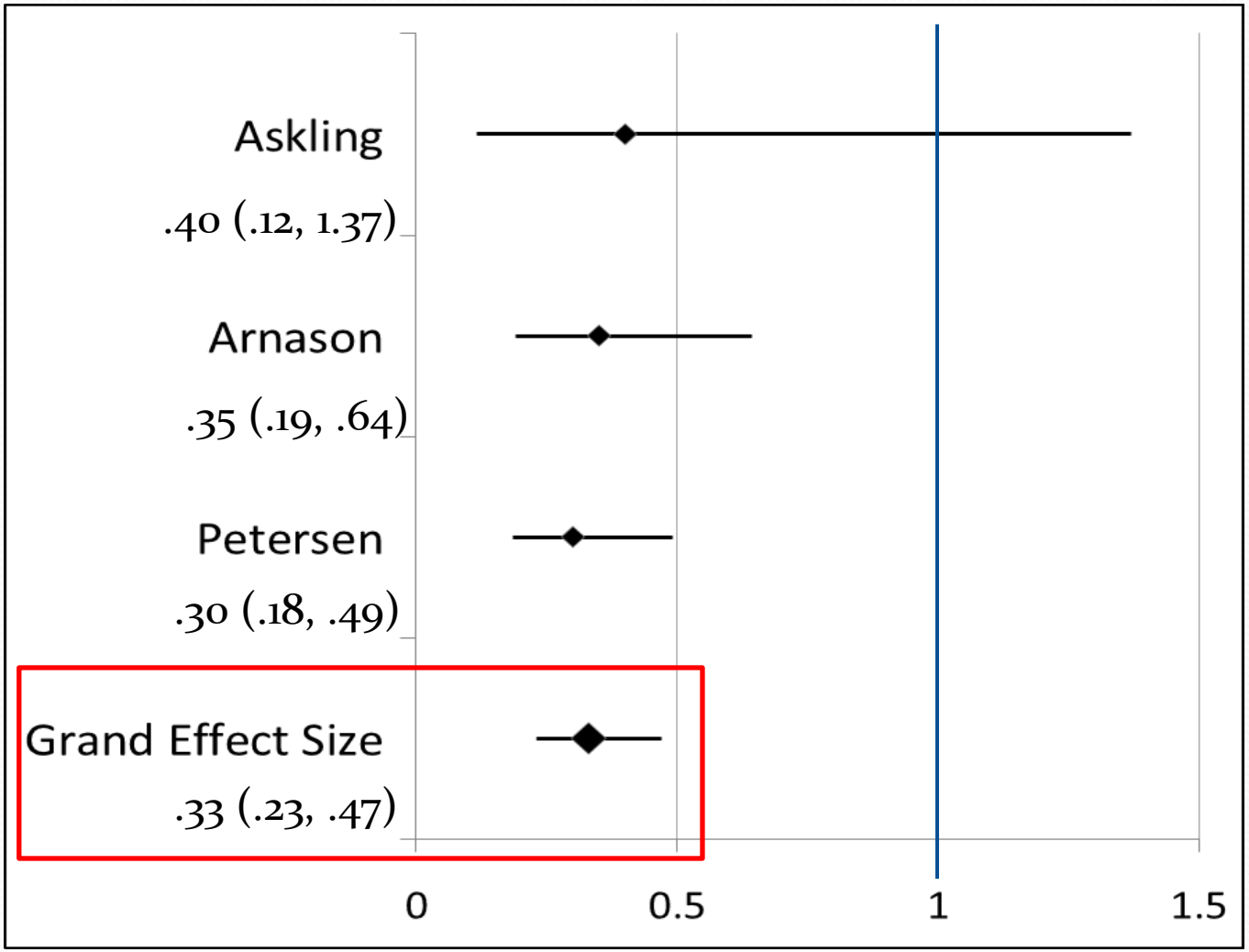
Forest Plot: RR of Hamstring Strain



Data Analysis: Outlier Gabbe

- Q with Gabbe: $P = 0.003 < .05$
  - Random effects model
- Q without Gabbe: $P = .881 > .05$
  - Fixed effect model

Forest Plot: RR Without Gabbe



Discussion

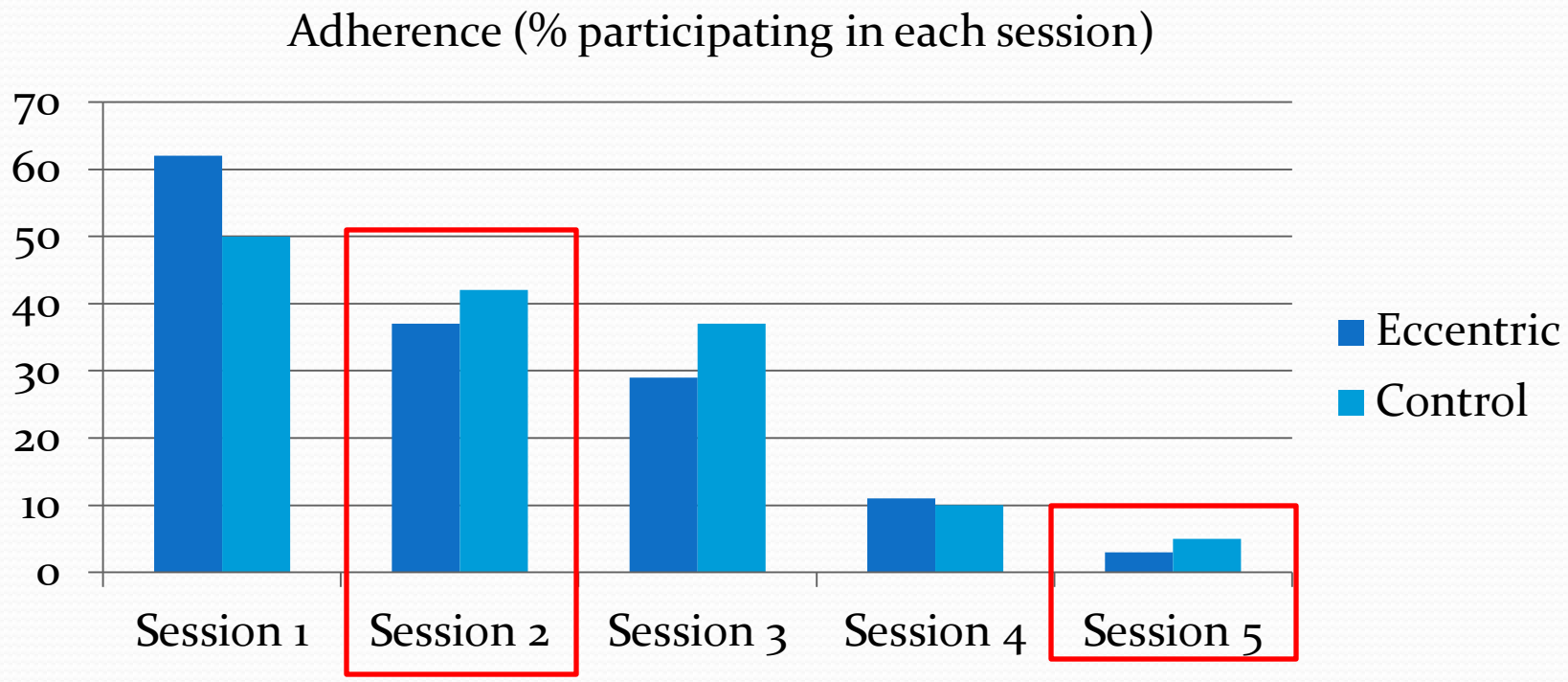
- Expectations met
  - Number of studies
  - Quality of studies

- Expectations not met
  - RR (95% CI) = .58 (.31, 1.07)
  - Fail to reject null hypothesis
    - No difference in rate of hamstring strain injury
    - Trend?
    - Preventative or not?

RR without Gabbe

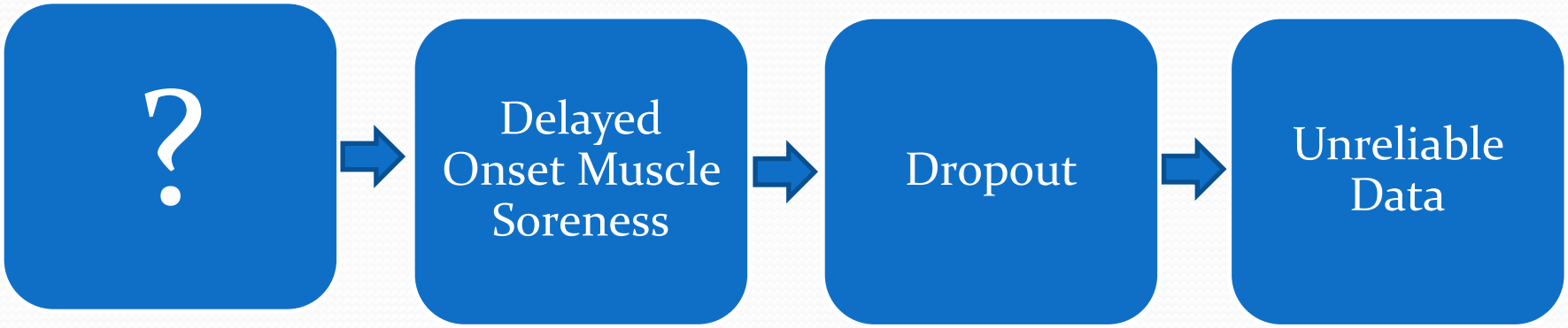
- RR (95% CI) = .33 (.23, .47)
  - Eccentric hamstring strengthening
    - 3 times less likely to have hamstring strain
    - 95% CI = 2 to 4 times less likely

Analysis of Gabbe



- Intention to treat: RR (95% CI) = 1.20 (.66, 2.16)
- At least first 2 sessions: RR (95% CI) = .30 (.10, 1.40)

Analysis of Gabbe



Harm

- Petersen: No adverse events
- Arnason: No adverse events

- Gabbe: Delayed onset muscle soreness (DOMS)
- Askling: DOMS

Cause of DOMS

Study	Intervention	Protocol	Reps Per Session
Arnason et al.	Nordic	Week / Sessions/Week / Sets and Reps 1 / 1 / 2 x 5 2 / 2 / 2 x 6 3 / 3 / 3 x 6-8 4 / 3 / 3 x 8-10 5-10 / 3 / 3 x 12/10/8 10+ / 1 / 3 x 12/10/8	Progressive: 10 - 30
Askling et al.	Yoyo™ flywheel	10 weeks, 16 sessions Weeks 1-4: Every 5th day Weeks 5-10: Every 4th day Session: 4 sets of 8 reps with 1 minute breaks between sets	Constant: 32
Gabbe et al.	Nordic	12 weeks, 5 sessions Session: 12 sets of 6 reps with 10 second rest between reps and 2-3 minute rest between sets	Constant: 72
Petersen et al.	Nordic	Same as Arnason et al.	Progressive: 10 - 30

Examining Askling

- RR (95% CI) = .40 (.12, 1.37)
  - DOMS but no dropout
  - Small N
  - Yoyo™ flywheel
  - Length of intervention

Length of Intervention

Study	Intervention	Protocol
Arnason et al.	Nordic	Week / Sessions/Week / Sets and Reps 1 / 1 / 2 x 5 2 / 2 / 2 x 6 3 / 3 / 3 x 6-8 4 / 3 / 3 x 8-10 5-10 / 3 / 3 x 12/10/8 10+ / 1 / 3 x 12/10/8
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Gabbe et al.	Nordic	12 weeks, 5 sessions Session: 12 sets of 6 reps with 10 second rest between reps and 2-3 minute rest between sets
Petersen et al.	Nordic	Same as Arnason et al. 10+

Petersen: Primary vs Secondary Prevention and Clinical Implications

- New hamstring strain
  - RR (95% CI) = .41 (.18, .93)
  - Clinical implications
    - Standard training
    - At risk: older, ↓ hip flexion AROM, ↓ eccentric strength

- Recurrent hamstring strain
  - RR (95% CI) = .14 (.04, .51)
  - Clinical implications
    - Rehabilitation
    - History of hamstring strain

Cost

- Studies did not address cost
- Time
- Equipment
  - Yoyo flywheel: $2,850
  - Nordic: none

Clinical Implications: Intervention

Intervention	RR (95% CI)	Cost
Nordic	.35 (.19, .64) .30 (.18, .49)	$0
Yoyo™ Flywheel	.40 (.12, 1.37)	$2,850

- Protocol
  - Progressive
    - Low reps per session
  - Continue intervention throughout season

Limitations: Search Method

- 2 databases
- Exclusion criteria
  - Poor participation
- Inclusion criteria
  - High level male athletes
    - Generalizability?
- Novice Researcher

Limitations: Individual Studies

- Arnason
  - Prospective cohort, not randomized
- Askling
  - Small N
- Gabbe
  - Poor participation
- Petersen
  - None

Directions for Future Research

- Nordic RCTs
  - Stretching
  - Concentric

- Population
  - Recreational athletes
  - Track athletes
  - Women
  - Children/adolescents

Conclusion

- Eccentric hamstring strengthening does not significantly reduce the risk of hamstring strain amongst high level adult male athletes

However…

- Trend toward preventative effect
- Significant ↓ RR when study with poor adherence excluded

So…

- More research is needed
- Nordic eccentric strengthening is a safe and cost effective intervention that is *likely* to reduce the risk of hamstring strains

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- George Haras, DPTc

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Questions?