



2022 NSCA *NATIONAL* CONFERENCE

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#NSCACon22

› *KNOWLEDGE*
› *ADVANCEMENT*
› *COMMUNITY*

CONFLICT OF INTEREST STATEMENT

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What is Science?

- “A discipline, field of study, or activity concerned with theory rather than method, or requiring the knowledge and systematic application of principles, rather than relying on traditional rules, acquired skill, or intuition.”
- “A branch of study that deals with a connected body of demonstrated truths or with observed facts systematically classified and more or less comprehended by general laws, and incorporating trustworthy methods (now especially those involving the scientific method and which incorporate falsifiable hypotheses) for the discovery of new truth in its own domain.”

Oxford English Dictionary

[oed.com/view/Entry/172672](https://www.oed.com/view/Entry/172672)

Power

- Weightlifting movements (snatch, clean, jerk) exhibit high power outputs
- Therefore, training with weightlifting movements will make an athlete more powerful
- Similarly, training with other exercises that exhibit high power outputs will make an athlete more powerful



Optimal Power Production Load = Optimal Training Load

- Training at the load that maximizes power output is more effective for performance than lighter or heavier loads
 - Kaneko et al. (1983) Scand J Sport Sci
 - Wilson et al. (1993) Med Sci Sports Exerc
- What load optimizes power output?
 - 30% MVC; Kaneko et al. (1983), Wilson et al. 1983
 - Jump squat: 47-63% 1 RM
 - Baker et al. (2001a) J Strength Cond Res
 - Bench press throw: 46-62% 1 RM
 - Baker et al. (2001b) J Strength Cond Res

Optimal Load for Power Production – Jumping



- Power output during vertical jumping is similar or greater than in the hang power clean
 - Hori et al. (2007) J Strength Cond Res
- Greatest power output occurs during jump squats with no additional external load
 - Body mass contributes to the total load
 - Cormie et al. (2007) Med Sci Sports Exerc

Is Power Training More Effective Than Strength Training?

- Power training group (n = 10)
 - Jump squats @ 0% 1 RM (back squat)
 - Strength/power training group (n = 8)
 - Jump squats @ 0% 1 RM (back squat)
 - Back squats @ 90% 1 RM
 - Control group (n = 8)
- 1 RM back squat
 - Increase in strength/power training group
 - Power output @ 0 kg and 20 kg load
 - Increase in power training and strength/power training groups
 - Power output @ 40 kg, 60 kg, and 80 kg
 - Increase in strength/power training group only

Cormie et al. (2007) Med Sci Sports Exerc

Is Power Training More Effective Than Strength Training?

- Power training group (n = 8)
 - Jump squats @ 0% & 30% 1 RM (back squat)
- Strength training group (n = 8)
 - Back squats @ 75%, 80%, & 90% 1 RM
- Control group (n = 8)
- Jump height
 - Power and strength training groups increased 6 ± 4 cm
- 40-m sprint
 - Both groups decrease sprint time

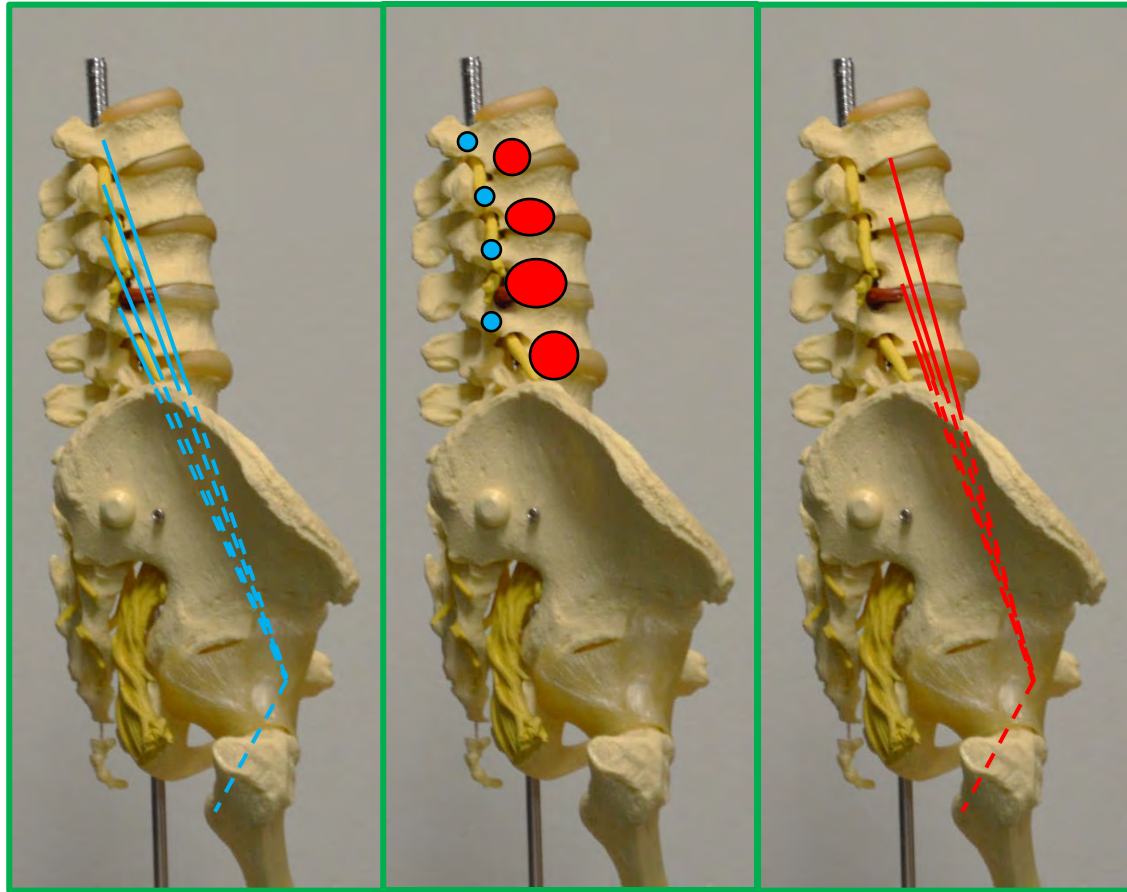
Cormie et al. (2010) Med Sci Sports Exerc

Is There an Optimal Load for Training?

- “Power”
 - A range of loads are effective for improving performance in high velocity tasks (jumping, sprinting, etc.)
- Muscular strength
 - A range of loads are effective for eliciting strength adaptations
- Hypertrophy
 - A range of loads are effective for eliciting muscle hypertrophy



Types of Knowledge (or Theories)



Lines of pull for the psoas major muscle, from which the muscle's anatomical actions are **deduced**

- Deductive reasoning/logic
 - A sequence of premises, starting with an accepted truth or axiom, is used to predict specific knowledge
- Inductive reasoning/logic
 - Observations made on a specific phenomenon are used to infer general knowledge
- Scientific knowledge

Example of Deductive Reasoning



“Hip Dominant”?

“Knee Dominant”?

- Accepted truth:
 - Bent forward or “stoop” postures use the hip and back muscles
 - Upright or “squat” postures use the quadriceps
- Conventional deadlifts and low bar squats are “hip dominant” exercises
- High bar squats and front squats are “knee dominant” exercises

Example of Inductive Reasoning

- Hip extensor NJM increases with greater load, and with greater squat depth
 - Bryanton et al. (2012) J Strength Cond Res
- Hip extensor NJM increases with a greater forward trunk lean or with greater squat depth
 - Chiu et al. (2016) J Sports Sci
- Therefore, the hip extensor muscles may be trained using heavier loads, stoop postures, or deep squat postures



What is Scientific Knowledge?

- Knowledge from deduction or induction are not scientific knowledge
 - Confirmation bias
- “The test of all knowledge is experiment. Experiment is the sole judge of scientific ‘truth.’” p. 2
 - Feynman (2011) Six Easy Pieces. Basic Books, New York
- What is an experiment?
 - Independent (manipulated) variable
 - Dependent (responding) variable

Example of a Strength Training Scientific Experiment

- Independent variable
 - Full squat training group (n = 8)
 - Half squat training group (n = 9)
- Dependent variables
 - Muscle volume for gluteus maximus, adductor, hamstrings, quadriceps muscles
- Controlled variables
 - 10 weeks, 2 days/week training program
- Results
 - **Vasti** volume increased ~5% in both groups
 - **Rectus femoris** volume did not increase in either group
 - **Hamstrings** volume did not increase in either group
 - **Adductor** volume increased ~2% in half squat and ~6% in full squat group
 - **Gluteus maximus** volume increased ~2% in half squat and ~6.5% in full squat group

Kubo et al. (2019) Eur J Appl Physiol

Scientific Knowledge of Squat Exercise

Inductive Reasoning	Experimental Findings	Status
Quadriceps loading increases with squat depth, therefore deep squats are more effective for training the quadriceps than shallow squats ^{b,c,d}	Vastus lateralis muscle thickness increases more in full v. partial squats ^a Vasti volume increases equally in full v. partial squats ^e	Contradictory evidence
Hip extensor loading increases with squat depth, therefore full squats are neither “hip” nor “knee” dominant ^{b,d}	Gluteus maximus and adductor muscle volumes increase more in full v. partial squats ^e	Evidence in support
Due to co-contraction at the knee, hamstrings contribution to squatting is minimal and the primary hip extensors are monoarticular muscles ^c	Squat exercise elicits gluteus maximus and adductor hypertrophy, but not hamstrings hypertrophy ^e	Evidence in support

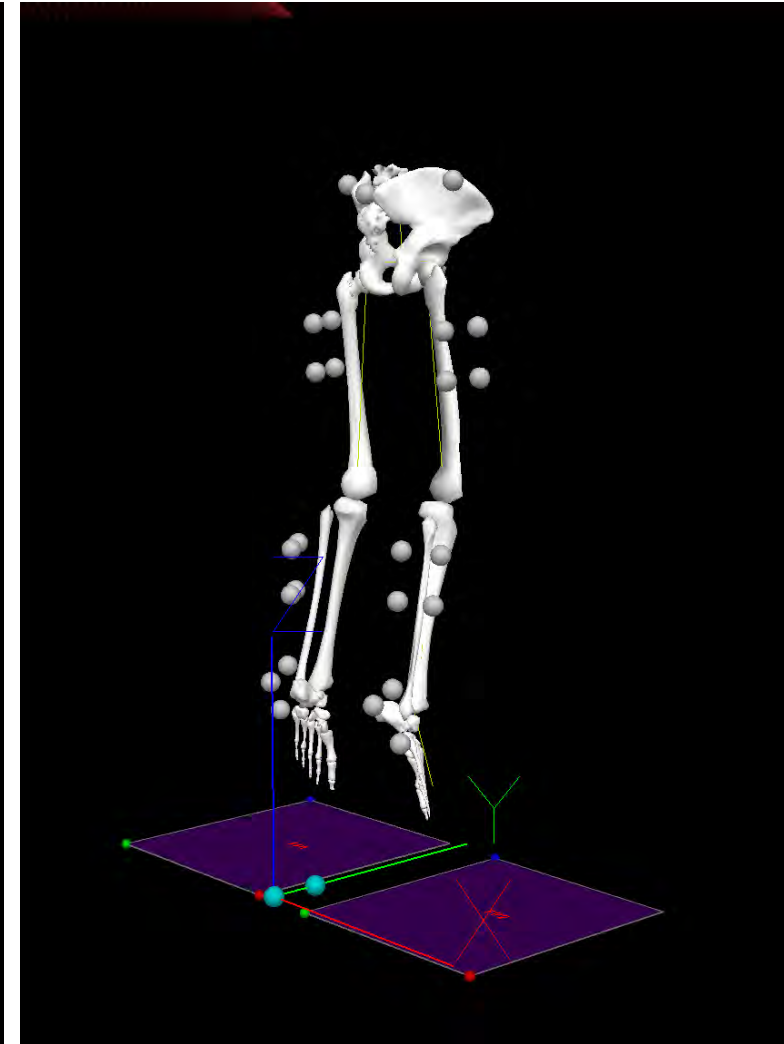
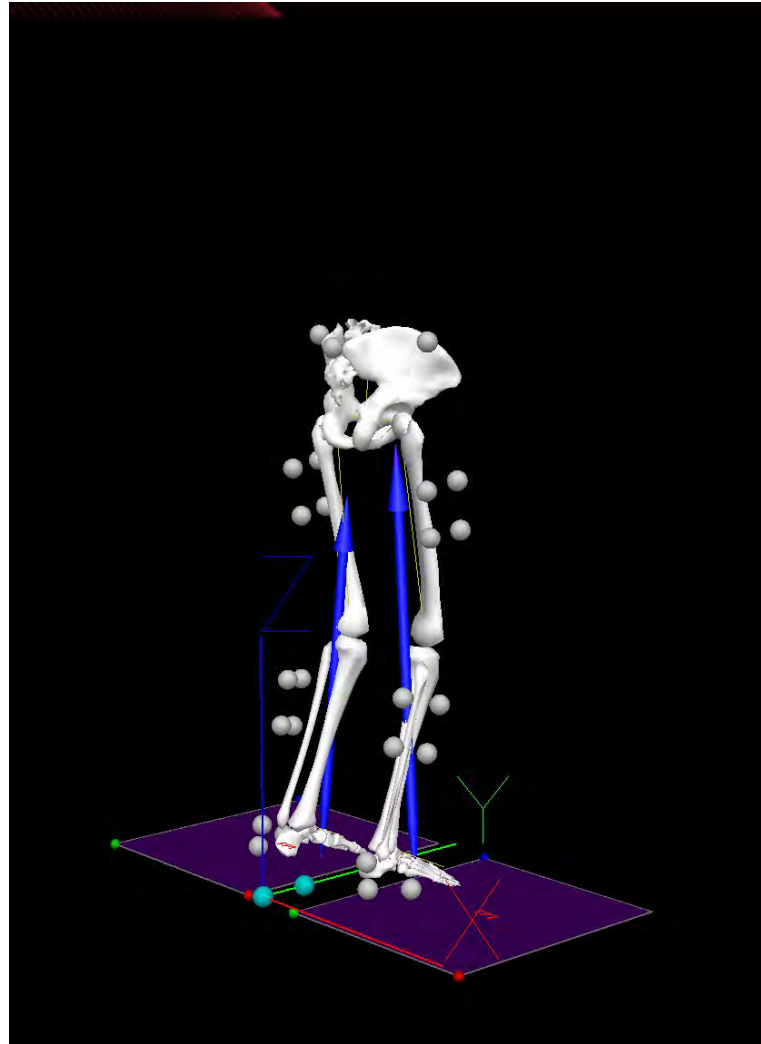
^aBloomquist et al. (2012) Int J Sports Med ^cBryanton et al. (2015) Sports Biomech

^bBryanton et al. (2012) J Strength Cond Res ^dChiu et al. (2016) J Strength Cond Res

^eKubo et al. (2019) Eur J Appl Physiol

Research Study Types

- Observational
 - Single
 - Longitudinal
- Comparative
- Correlational
- **Experimental**
 - Acute
 - Short- to long-term



(True) Experimental Research in Strength & Conditioning

- Training intervention studies
- Most questions in strength and conditioning relate to eliciting adaptations from training
- Examples:
 - Is exercise A more/less effective than exercise B?
 - Is high ____ more/less effective than low ____?

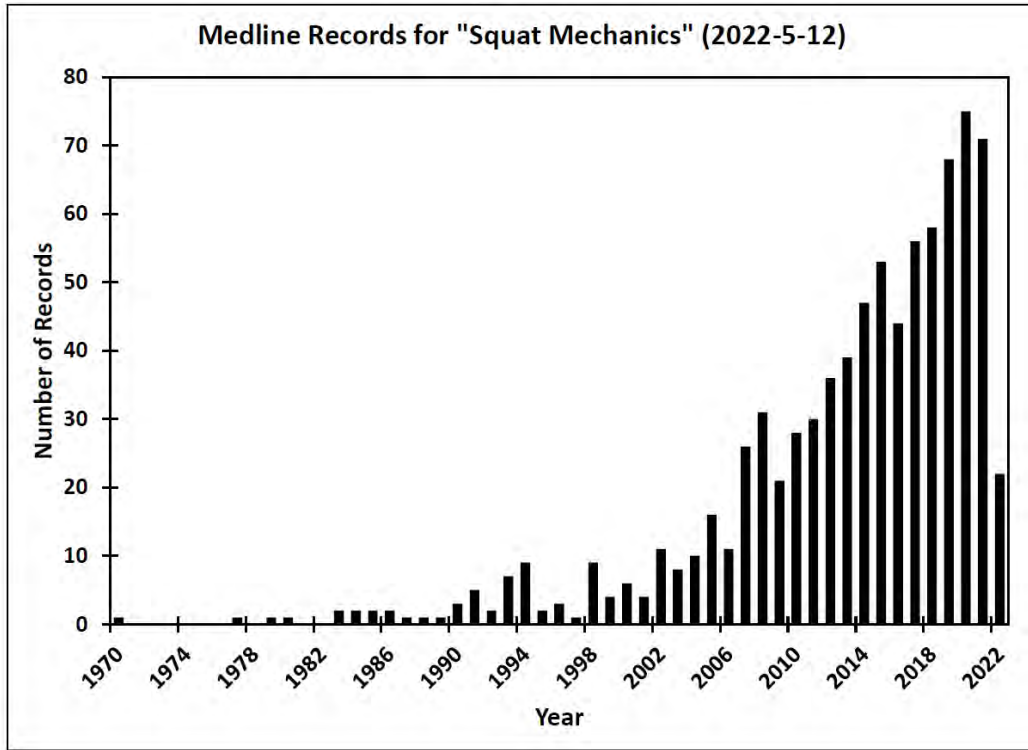
Table 2: Periodized Exercise Program

Week 1 (Neuromotor)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Isometric Quadriceps Activation	NA / 5 * 5	NA / 5 * 5	NA / 5 * 5	
Sit-to-Stand	NA / 3 * 5	NA / 3 * 5	NA / 3 * 5	
Supine Leg Lower	NA / 5 * 3	NA / 6 * 3	NA / 6 * 3	
Unilateral Heel Raise	NA / 6 * 3	NA / 6 * 3	NA / 6 * 3	
Week 2 (Neuromotor)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Isometric Quadriceps Activation	NA / 5 * 5			
Sit-to-Stand	NA / 5 * 5	NA / 5 * 5	NA / 5 * 5	
Plate Squat*	10 kg / 8 * 3	10 kg / 8 * 3	10 kg / 8 * 3	
Good Morning with Dowel		NA / 5 * 5	NA / 5 * 5	
Supine Leg Lower	Deadlift			
Unilateral Heel Raise	Supine Leg Lower			
Supine Glute Bridge	Unilateral Heel Raise			
Week 3 (Muscle Hypertrophy)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Isometric Quadriceps Activation	NA / 5 * 5			
Sit-to-Stand	NA / 5 * 5	NA / 5 * 5	NA / 5 * 5	
Plate Squat*	10 kg / 8 * 3	10 kg / 8 * 3	10 kg / 8 * 3	
Good Morning with Dowel		NA / 5 * 5	NA / 5 * 5	
Supine Leg Lower	Deadlift			
Unilateral Heel Raise	Supine Leg Lower			
Supine Glute Bridge	Unilateral Heel Raise			
Week 4 (Muscle Hypertrophy)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Isometric Quadriceps Activation	NA / 5 * 5			
Sit-to-Stand	NA / 5 * 5	NA / 5 * 5	NA / 5 * 5	
Plate Squat*	10 kg / 8 * 3	10 kg / 8 * 3	10 kg / 8 * 3	
Good Morning with Dowel		NA / 5 * 5	NA / 5 * 5	
Supine Leg Lower	Deadlift			
Unilateral Heel Raise	Supine Leg Lower			
Supine Glute Bridge	Unilateral Heel Raise			
Week 5 (Muscle Hypertrophy)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Isometric Quadriceps Activation	NA / 5 * 5			
Sit-to-Stand	NA / 5 * 5	NA / 5 * 5	NA / 5 * 5	
Plate Squat*	10 kg / 8 * 3	10 kg / 8 * 3	10 kg / 8 * 3	
Good Morning with Dowel		NA / 5 * 5	NA / 5 * 5	
Supine Leg Lower	Deadlift			
Unilateral Heel Raise	Supine Leg Lower			
Supine Glute Bridge	Unilateral Heel Raise			
Week 6 (Muscle Hypertrophy)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Isometric Quadriceps Activation	NA / 5 * 5			
Sit-to-Stand	NA / 5 * 5	NA / 5 * 5	NA / 5 * 5	
Plate Squat*	10 kg / 8 * 3	10 kg / 8 * 3	10 kg / 8 * 3	
Good Morning with Dowel		NA / 5 * 5	NA / 5 * 5	
Supine Leg Lower	Deadlift			
Unilateral Heel Raise	Supine Leg Lower			
Supine Glute Bridge	Unilateral Heel Raise			
Week 7 (Muscle Strength)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Plate Squat*	15 kg / 5 * 3	15 kg / 5 * 3	15 kg / 5 * 3	
Front Squat	6 RM / 5 * 5	5 RM / 3 * 5	5 RM / 3 * 5	
Deadlift		5 RM / 3 * 4		
Sit-Up	NA / 8 * 3		NA / 8 * 4	
Abdominal Crunch				
Unilateral Heel Raise				
Supine Glute Bridge				
Week 8 (Muscle Strength)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Plate Squat*	15 kg / 5 * 3	15 kg / 5 * 3	15 kg / 5 * 3	
Front Squat	3 RM / 3 * 5, 10 RM / 10 * 3	4 RM / 4 * 5	3 RM / 3 * 5, 10 RM / 8 * 3	
Deadlift		3 RM / 3 * 3		
Sit-Up	NA / 12 * 3			
Abdominal Crunch		10 kg / 8 * 3	10 kg / 8 * 2	
Unilateral Heel Raise	9 kg / 12 * 3	9 kg / 12 * 3	7 kg / 12 * 4	
Supine Glute Bridge	NA / 12 * 3			
Week 9 (Muscle Strength)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Plate Squat*	15 kg / 5 * 3	15 kg / 5 * 3	15 kg / 5 * 3	
Front Squat	3 RM / 3 * 5, 10 RM / 10 * 3	4 RM / 4 * 5	3 RM / 3 * 5, 10 RM / 8 * 3	
Deadlift		3 RM / 3 * 3		
Sit-Up	NA / 12 * 3			
Abdominal Crunch		10 kg / 8 * 3	10 kg / 8 * 2	
Unilateral Heel Raise	9 kg / 12 * 3	9 kg / 12 * 3	7 kg / 12 * 4	
Supine Glute Bridge	NA / 12 * 3			
Week 10 (Muscle Strength)				
Exercise	Day 1 (Load/Repetitions*Sets)	Day 2 (Load/Repetitions*Sets)	Day 3 (Load/Repetitions*Sets)	
Plate Squat*	15 kg / 5 * 3	15 kg / 5 * 3	15 kg / 5 * 3	
Front Squat	3 RM / 3 * 5, 10 RM / 10 * 3	4 RM / 4 * 5	3 RM / 3 * 5, 10 RM / 8 * 3	
Deadlift		3 RM / 3 * 3		
Sit-Up	NA / 12 * 3			
Abdominal Crunch		10 kg / 8 * 3	10 kg / 8 * 2	
Unilateral Heel Raise	9 kg / 12 * 3	9 kg / 12 * 3	7 kg / 12 * 4	
Supine Glute Bridge	NA / 12 * 3			

Notes: Plate Squat* - the control group performed the traditional variation and the experimental group performed the non-involved limb elevated variation. NA indicates no external load. Loads for the front squat and back squat were based on the "repetition maximum", i.e. the maximum load that could be lifted for the number of repetitions listed.

Jean et al. (2022) J Strength Cond Res

Chaos in the Brickyard



Retrieved from: <https://pubmed.ncbi.nlm.nih.gov/>

- Forscher (1963) Science
 - Bricks – research studies (data, evidence, etc.)
 - Edifice – scientific knowledge
 - End goal has shifted from building an edifice to making bricks
 - To make more bricks, quality is sacrificed
- How many of the records in the graph do you think are true experimental studies?

How Deep Should One Squat?



- Weiss et al. (2000) J Strength Cond Res
 - Parallel squat increases squat strength more than shallow squat
- Hartmann et al. (2012) J Strength Cond Res
 - Full squat increases squat strength and vertical jump height more than partial squat (60° knee flexion)
- Bloomquist et al. (2012) Int J Sports Med
 - Full squat increases knee extensor strength, quadriceps size, and vertical jump height more than partial squat (60° knee flexion)
- Kubo et al. (2019) Eur J Appl Physiol
 - Full and half squat (90° knee flexion) increase vasti muscle size, but not rectus femoris or hamstrings
 - Full squat increases gluteus maximus and adductor muscle size more than half squat

Squatting Chaos!

- “Selecting assistive exercises for female athletes who isolate the BF (biceps femoris) may be a better approach to posterior chain strengthening in women than the traditional back squat” p. 313
 - Mehls et al. (2022) J Strength Cond Res 36(2):310-313
- “... the results about individual muscle contributions to the overall NJMs (net joint moments) suggest that with respect to hip joint mechanics, **subjects execute the back squat with large muscle moment contributions from the hamstring and gluteus maximus muscles but not the adductor magnus**, which has important implications for the program design process where exercises are selected based on the mechanical demands that they impose on the neuromusculoskeletal system.” p. 329
 - Kipp et al. (2022) J Strength Cond Res 36(2):324-331

Hunting For Vulcan

- Mercury and Uranus do not follow planetary orbits as predicted from Newton's Principia
 - Vulcan and Neptune were predicted to exist; their gravitational effects explained the orbits of Mercury and Uranus, respectively
 - Neptune was observed the same night it was predicted to exist (1846-09-23)
 - Most astronomers gave up the hunt for Vulcan by 1890
- Alternatives to Vulcan
 - Modify Newton's Law of Universal Gravitation
 - $F_G = G \frac{m_1 m_2}{r^2} \rightarrow F_G = G \frac{m_1 m_2}{r^{2.0000001574}}$
 - Einstein proposes the Theory of General Relativity
 - In 1914 a German expedition aiming to confirm the theory's hypothesis that the Sun's mass would bend light ran into astronomers still hunting for Vulcan*

*Levenson (2015) The Hunt for Vulcan. Random House, New York.

How to be a Good Scientist

- Read
 - A lot
 - Frequently
 - Outside your discipline
 - A given topic cannot be understood from one perspective
 - Break down walls and barriers

How to be a Good Scientist

- Read
- Distinguish between bricks and edifices
- Is the knowledge on a topic deductive or inductive?
 - Is this knowledge logical or can it be explained differently?
- Is there experimental evidence to support (or refute) the knowledge
- How strong is the evidence?
 - Measurement techniques
 - Experimental design

How to be a Good Scientist

- Read
- Distinguish between bricks and edifices
- Accept that you could be wrong
- “Only a Sith deals in absolutes” (Obi-Wan Kenobi)
 - McCallum, R., Lucas, G., Christensen, H., McGregor, E., Portman, N., Lucasfilm, Ltd., & Twentieth Century Fox Home Entertainment, Inc. (2011). *Star Wars: Episode III*.
- Surround yourself with people who will tell you that you’re wrong
- Attempt to disprove your theories
- Conduct (true) experimental studies

Why Aren't There More Experimental Studies?

- Time
- Expense
- Lack of recognition

Why Aren't There More Experimental Studies?

- Time
- Expense
- Lack of recognition

Stop making excuses

1. Chiu et al. (2017) J Strength Cond Res
2. vonGaza & Chiu (2021) J Strength Cond Res
3. Jean et al. (2022) J Strength Cond Res
4. Dæhlin (2022) PhD Thesis

Make the Most of Your Experimental Studies

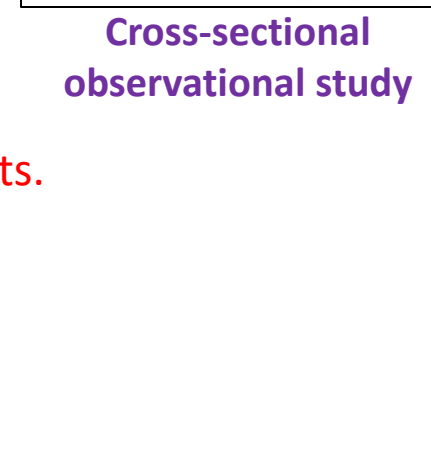
- Use other research to inform your study rationale and experimental design
- Where there are gaps, conduct non-experimental studies to build up to an experimental study
- Search for large differences
 - “Whenever there is any doubt, there is no doubt”
 - Frankenhimer, J. (1998). Ronin. United Artists.
- Statistical significance is only the first step
 - If it’s “borderline” or “trending towards” significance, the difference is not meaningful



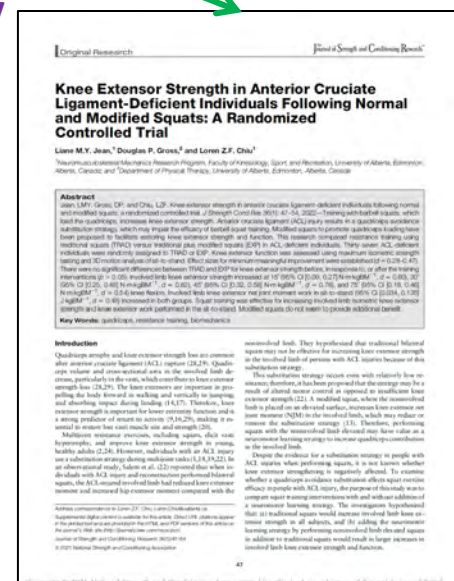
Cross-sectional comparative study



Cross-sectional comparative study



Experimental (RCT) study



Incline v. Block Heel Raise



- Midfoot NJM ($p < 0.05$; $d = 0.58-0.59$)
- Ankle plantar flexor NJM ($p < 0.05$; $d = 0.66-0.67$)
 - Chiu & Dæhlin (2021) J Strength Cond Res
- Based on moderate effect size differences, hypothesized that incline heel raise would be more effective for strengthening the foot arch elevator muscles and the triceps surae
- No difference in effect following 11-weeks training
 - Dæhlin (2022) PhD Thesis

Normal v. Experimental Squat for ACL-Injured



- Knee extensor NJM in the involved limb was greater in the experimental than normal squat ($p < 0.05$; $d = 0.57$)
 - Jean & Chiu (2021) J Strength Cond Res
- From a moderate effect size difference, it was hypothesized that addition of experimental squats to training would enhance knee extensor strength increases
- No difference in effect following 10-weeks training
 - Jean et al. (2022) J Strength Cond Res

Identify Meaningful Differences

- Differences that are not meaningful will not result in differences in an experimental study
 - Small differences can be washed out by other factors
- What is a meaningful difference?
 - $P \leq 0.05$
 - 95% confidence interval of the difference
 - Standardized effect size (Cohen's d ; Hedges' g ; etc.)
 - Non-standardized effect size (absolute change)
 - **Other?**

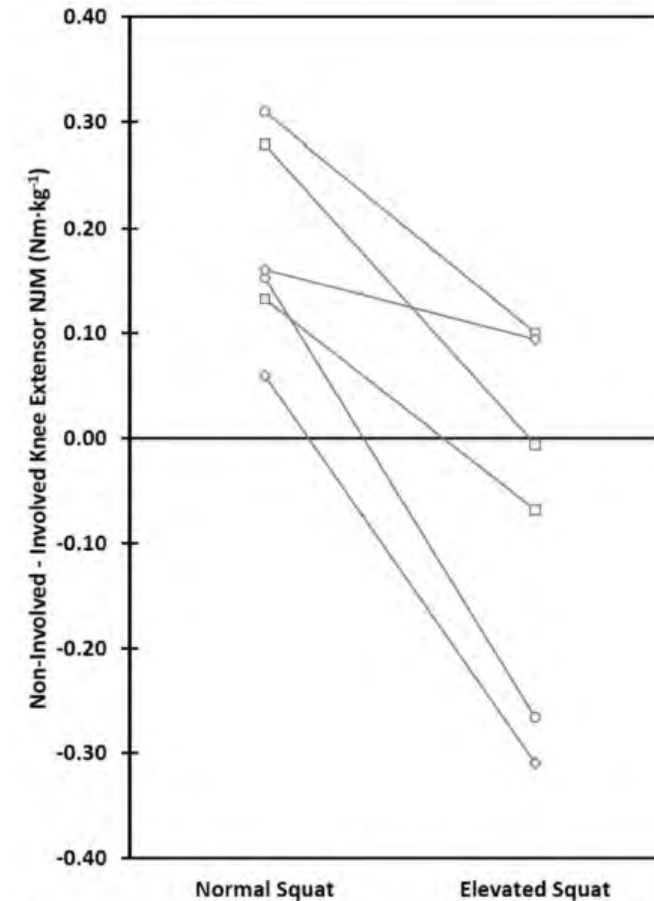


Figure 6. Noninvolved limb minus involved limb knee extensor net joint moment during normal and noninvolved limb elevated squats for individual subjects.

Alternative approach to show consistency of response for all participants

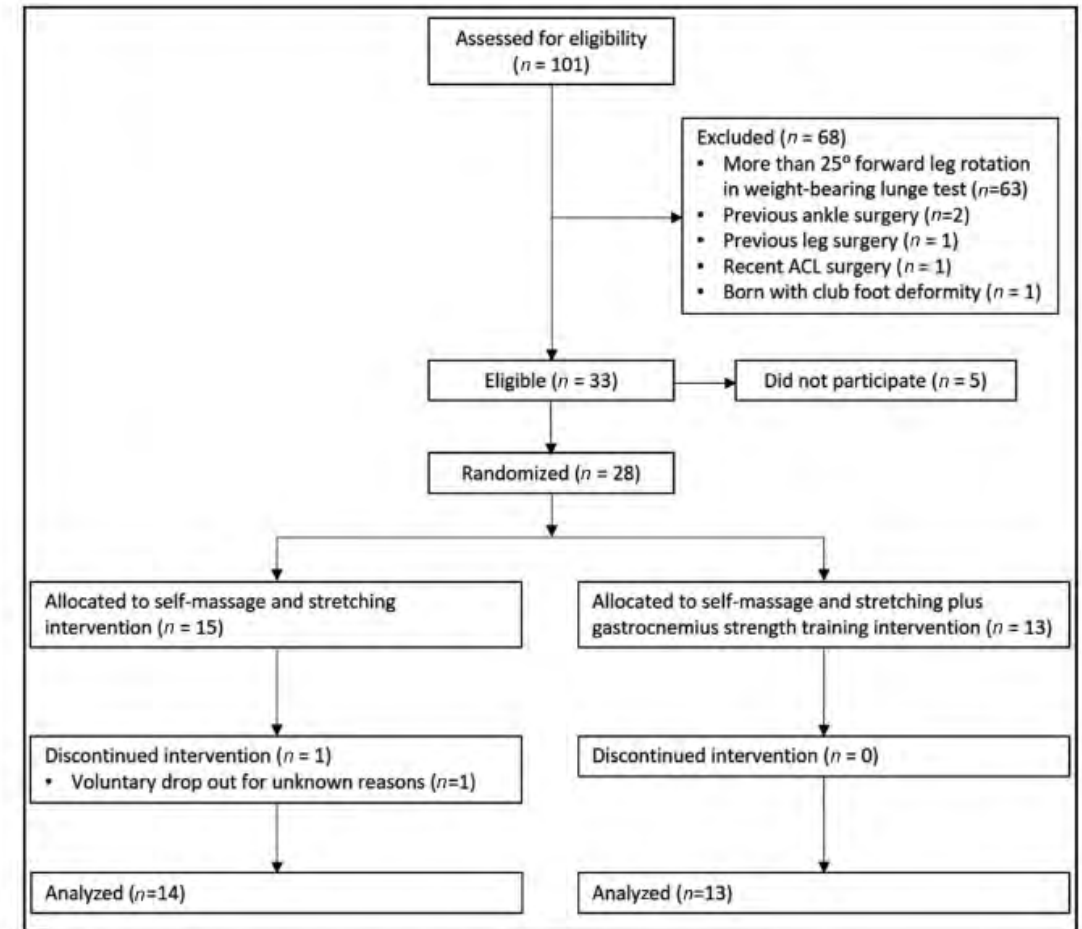
From: Jean & Chiu (2021) J Strength Cond Res

Sample Size

- Statistically, sample size is coupled to effect size
 - Small effects require large samples to find statistical significance
 - Large effects require small samples to find statistical significance
- Since a meaningful difference is a large effect size, is a small sample size sufficient?
 - No
 - Small samples do not allow generalizability
 - Small samples limit heterogeneity

Experimental Study Design

1. Independent variable
 - a) Conditions are meaningfully different
2. Sample size
 - a) Larger is better than smaller
 - b) Reliability and SEM
3. Dependent variable
 - a) Primary dependent variable – the “so what” question
 - b) Secondary dependent variables – mechanisms
4. Study registration & CONSORT



vonGaza & Chiu (2021) J Strength Cond Res

*Example of flow diagram, part of the Consolidated Standards of Reporting Trials (CONSORT) guidelines

How to be a Good Scientist

- Read
- Distinguish between bricks and edifices
- Accept that you could be wrong
- Research reform
- Understand the role of different research study types
- Conduct experimental studies
- Manuscript and grant reviews
- Publication politics

Manuscript & Grant Reviews

- Study type
 - Experimental v. non-experimental
- Study rationale
 - Theory-driven or data gathering?
- Study design
 - Is the study designed to test the hypothesis?
 - Does the statistical design test the hypothesis?

Publication Politics

- Is this research important v. is this good research?
- Not a numbers game
- Who determines whether research is important?
- How long should we wait to decide whether research is or isn't important?

Publication Politics

- Is this research important v. is this good research?
- Not a numbers game
- “Big bang”
 - Describes theory of nucleosynthesis developed in 1948
 - Coined in 1949 by Fred Hoyle, a proponent of the “steady state” universe
 - Theory was widely criticized until late 1950’s
 - Accepted as best theory of the universe since 1960’s

Publication Politics

- Is this research important v. is this good research?
- Not a numbers game
- Ignore impact factor (& similar metrics)
 - How long until an idea is recognized?
 - Is your work cited positively or critically?
- Be wary of salami slicing
 - Multiple publications from one data set
 - You are obligated to explicitly state if you have submitted or previously published work from the same data set
 - You must then justify why a second (or more) publication from that data set is justified

Why Strength & Conditioning Science is Important

- “But there is *one* feature I notice that is generally missing in **Cargo Cult Science**. That is the idea that we all hope you have learned in studying science in school—we never explicitly say what this *is*, but just hope that you catch on by all the examples of scientific investigation. It is interesting, therefore, to bring it out now and speak of it explicitly. It’s a kind of scientific **integrity**, a principle of scientific thought that corresponds to a kind of utter honesty—a kind of leaning over backwards.” p. 11
 - Feynman (1974) Eng Sci 37:10-13