The Squat

Chee Vang, DPT, OCS, CSCS TCO Sports Medicine Grand Rounds July 21, 2022





Review basic biomechanics of the squat

Instruct on the squat assessment/screen

Discuss and prescribe the squat-hinge continuum

Integrate concepts into clinical practice



- Force: causes or tends to cause motion
- Moment Arm: perpendicular distance from the applied force
- **Torque:** Moment or rotational force and leverage

Torque = Force x Moment Arm





Keogh et al. 2013

Knee Moment Arm





Hip Moment Arm











Keogh et al. 2013







Gaze: Where should they be looking? - Straight ahead or slightly upward

Trunk: What should the trunk do? - Maintain "neutral"/isometric position

Lower Quarter: Do they break at the hip or knee first?

- Hip: More hip dominant
- Knee: More knee dominant

Kritz et al. 2009, Fuglsang et al. 2017



TWIN CITIES ORTHOPEDICS

Sensory Competencies: How does it feel?

Motor Competencies: How does it look?

Kritz et al. 2009, Fuglsang et al. 2017





"Lack of ankle dorsiflexion range of motion."

"Lacks sufficient hip flexion."

"Lordosis positioning of the lumbar spine."

Kritz et al. 2009, Fuglsang et al. 2017



RTHOPEDICS





Choosing The Squat

What type of squat should be performed?

Squat-Hinge Continuum









Squat-Hinge Continuum



Squat Pattern





More Knee Flexion Less





Hinge Pattern

Prescribing The Squat

Can the knees pass the toes?

How deep should we squat?

Should my stance be narrow or wide?





Effect of Knee Position on Hip and Knee Torques During the Barbell Squat 2003 National Strength & Conditioning Association







- Knee Torque: 150.1+50.8 (p < 0.05)
- Hip Torque: 28.2+65.0 (p < 0.05)

- Knee Torque: 117.3+34.2 (p < 0.05)
- Hip Torque: 302.7+71.2 (p < 0.05)

Effect of Knee Position on Hip and Knee Torques During the Barbell Squat



"Restricting anterior knee translation may minimize knee stress, but these forces may inappropriately transfer to the hips and low back. Optimal loading may require the knees to slightly pass the toes during squatting."

Can the knees pass the toes?

Biomechanical Model and Evaluation of a Linear Motion Squat Type Exercise

KEVIN G. ABELBECK Journal of Strength and Conditioning Research, 2002, 16(4), 516–524 © 2002 National Strength & Conditioning Association

Cruciate Ligament Force during the Wall Squat and the One-Leg Squat

RAFAEL F. ESCAMILLA¹, NAIQUAN ZHENG², RODNEY IMAMURA³, TORAN D. MACLEOD⁴, W. BRENT EDWARDS⁵, ALAN HRELJAC³, GLENN S. FLEISIG⁶, KEVIN E. WILK⁷, CLAUDE T. MOORMAN III⁸, and JAMES R. ANDREWS^{6,9} Medicine & Science in Sports & Exercise₈

A BIOMECHANICAL COMPARISON OF BACK AND FRONT SQUATS IN HEALTHY TRAINED INDIVIDUALS

JONATHAN C. GULLETT, MARK D. TILLMAN, GREGORY M. GUTIERREZ, AND JOHN W. CHOW

Journal of Strength and Conditioning Research © 2009 National Strength and Conditioning Association

Cruciate Ligament Forces between Short-Step and Long-Step Forward Lunge

RAFAEL F. ESCAMILLA¹, NAIQUAN ZHENG², TORAN D. MACLEOD³, RODNEY IMAMURA⁴, W. BRENT EDWARDS⁵, ALAN HRELJAC⁴, GLENN S. FLEISIG⁶, KEVIN E. WILK⁷, CLAUDE T. MOORMAN III⁸, LONNIE PAULOS¹, and JAMES R. ANDREWS^{1,6} Medicine & Science in Sports & Exercise_n



A BIOMECHANICAL COMPARISON OF THE TRADITIONAL SQUAT, POWERLIFTING SQUAT, AND BOX SQUAT

PAUL A. SWINTON,¹ RAY LLOYD,² JUSTIN W. L. KEOGH,^{3,4} IOANNIS AGOURIS,¹ AND ARTHUR D. STEWART⁵ Journal of Strength and Conditioning Research © 2012 National Strength and Conditioning Association

A pilot study of the eccentric decline squat in the management of painful chronic patellar tendinopathy C R Purdam, P Johnsson, H Alfredson, R Lorentzon, J L Cook, K M Khan

Br J Sports Med 2004;

Decline eccentric squats increases patellar tendon loading compared to standard eccentric squats

M Kongsgaard, P Aagaard, S Roikjaer, D Olsen, M Jensen, H Langberg, S P Magnusson Clin Biomech

Eccentric decline squat protocol offers superior results at 12 months compared with traditional eccentric protocol for patellar tendinopathy in volleyball players

M A Young, J L Cook, C R Purdam, Z S Kiss, H Alfredson Br J Sports Med 2005,

How deep should we squat?



Hartmann et al. 2013

Effect of range of motion in heavy load squatting on muscle and tendon

adaptations K. Bloomquist · H. Langberg · S. Karlsen · S. Madsgaard · M. Boesen · T. Raastad Eur J Appl Physiol (2013)

OBJECTIVE

Compare the effects on muscle cross sectional area (CSA) and lower extremity strength during squat training at varying depths.





Effect of range of motion in heavy load squatting on muscle and tendon

adaptations K. Bloomquist · H. Langberg · S. Karlsen · S. Madsgaard · M. Boesen · T. Raastad Eur J Appl Physiol (2013)



1 RM improved by 36% (p>0.05)

Effect of range of motion in heavy load squatting on muscle and tendon

adaptations K. Bloomquist · H. Langberg · S. Karlsen · S. Madsgaard · M. Boesen · T. Raastad Eur J Appl Physiol (2013)



"Training deep squats elicited favorable adaptations on knee extensor muscle size and function compared to training shallow squats."

Effects of squat training with different depths on lower limb muscle volumes

Keitaro Kubo¹ · Toshihiro Ikebukuro¹ · Hideaki Yata² European Journal of Applied Physiology (2019)

OBJECTIVE

Explore the effects of lower limb muscle volumes during squat training with varying depths.



Effects of squat training with different depths on lower limb muscle volumes

Keitaro Kubo¹ · Toshihiro Ikebukuro¹ · Hideaki Yata² European Journal of Applied Physiology (2019)



- 4.9% quadriceps increase (p<0.001)
- 6.2% adductor increase (p=0.026)
- 6.7% gluteus maximus increase (p=0.008)

- 4.6% quadriceps increase(p=0.003)
- 2.7% adductor increase (p=0.026)
- 2.2% gluteus maximus increase (p=0.008).

Effects of squat training with different depths on lower limb muscle volumes

Keitaro Kubo¹ · Toshihiro Ikebukuro¹ · Hideaki Yata² European Journal of Applied Physiology (2019)



"Full squat training is more effective than half squats at developing lower limb muscle cross sectional area volumes."

THE EFFECT OF STANCE WIDTH ON THE ELECTROMYOGRAPHICAL ACTIVITY OF EIGHT SUPERFICIAL THIGH MUSCLES DURING BACK SQUAT WITH DIFFERENT BAR LOADS

ANTONIO PAOLI,¹ GIUSEPPE MARCOLIN,¹ AND NICOLA PETRONE² Journal of Strength and Conditioning Research

2009 National Strength and Conditioning Association



Investigate the effects of three different stance widths and bar loads on electromyographic (EMG) activity of eight thigh muscles during the barbell back squat.

Greater Trochanteric (GT) Distance – Narrow Stance



1.5 Greater Trochanteric (GT) Distance – Moderate Stance



2 Greater Trochanteric (GT) Distance – Wide Stance



THE EFFECT OF STANCE WIDTH ON THE ELECTROMYOGRAPHICAL ACTIVITY OF EIGHT SUPERFICIAL THIGH MUSCLES DURING BACK SQUAT WITH DIFFERENT BAR LOADS

ANTONIO PAOLI,¹ GIUSEPPE MARCOLIN,¹ AND NICOLA PETRONE² Journal of Strength and Conditioning Research

2009 National Strength and Conditioning Association

RESULTS

- As load on the bar increased from 0 to 70% 1RM, EMG activation increased in all muscle groups.
- Gluteus maximus activation significantly increased at maximum squat width (2 GTd) (p < 0.05).

CONCLUSION

"A larger stance width is necessary for greater EMG activation of the gluteus maximus during the back squat."



Should my stance be narrow or wide?

Stance width and bar load effects on leg muscle activity during the parallel squat MEDICINE & SCIENCE IN SPORTS & EXERCISE

STEVEN T. MCCAW and DONALD R. MELROSE

A three-dimensional biomechanical analysis of the squat during varying stance widths

RAFAEL F. ESCAMILLA, GLENN S. FLEISIG, TRACY M. LOWRY, STEVEN W. BARRENTINE, and JAMES R. ANDREWS 2001 MEDICINE & SCIENCE IN SPORTS & EXERCISE.

How to squat? Effects of various stance widths, foot placement angles and level of experience on knee, hip and trunk motion and loading BMC Sports Science, Medicine and Rehabilitation (2018)

Silvio Lorenzetti^{1,2*}0, Mira Ostermann^{1,3}, Fabian Zeidler^{1,4}, Pia Zimmer^{1,4}, Lina Jentsch¹, Renate List¹, N CITIES William R. Taylor¹ and Florian Schellenberg¹



Squat Prescription





Squat Prescription - Volume



Staying at Consistent Loads

NAME:			
WEEKS	SETS	REPS	NOTES
1	2	10-12	Total Reps per exercise: 20-24
2	2	15	Total Reps per exercise: 30
3	2	20	Total Reps per exercise: 40
4	2	AMRAP (25 max)	Total Reps per exercise: 50
5	2	15	Total Reps per exercise: 30



Squat Prescription - Intensity







Squat Prescription – Time Under Tension







Squat Prescription – Depth







Squat Prescription – Velocity







Squat Prescription – Base of Support







Squat Prescription – Base of Support









Dynamic Knee Valgus

• Reactive Neuromuscular Training (RNT)



Anterior Knee Pain

 Graded Exposure – Positional Tolerance Loading



Posterior Pelvic Tilt

Neuromuscular Control Training



























TWIN CITIES ORTHOPEDICS

Summary - Prescribing The Squat

Can the knees pass the toes?

How deep should we squat?

Should my stance be narrow or wide?





Summary - Integration into Clinical Practice



Dynamic Knee Valgus

• Reactive Neuromuscular Training (RNT)



Anterior Knee Pain

 Graded Exposure – Positional Tolerance Loading



Posterior Pelvic Tilt

Neuromuscular Control Training

Summary

 Consider the individuals, specific task, and environmental factors as these are important to determine squat prescription prior to labelling dichotomies for the optimal squat.



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