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Comparative effects of full-depth (ATG) versus parallel squats on knee discomfort, perceived effort, technique, and delayed onset muscle soreness in trained lifters

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Abstract
Objective: To understand the effects of squat depth on knee discomfort, effort, and soreness.
Methods:
Study Design: Experimental Study
Sample Size: 15-20 Lifters
Inclusion: Lifters with >1 Year training experience
Exclusion: Recent Injury or surgery, chronic illness
Data Collection: Standardized squat sessions, discomfort scales, DOMS rating after 24-48 hrs.
Safety Precautions: Warm-up, spotters, supervised lifts.
Results
Effort: Lifters felt ATG squats were harder (mean 6.25 vs 3.72)
Discomfort: Mildly greater knee discomfort was seen in parallel squats (4.34 vs 3.31)
Technique: Scores were very similar, suggesting lifters maintained form in both depths.
DOMS: About one-third of participants felt muscle soreness after ATG squats, while few or none after parallel.
Conclusion: In this experimental study involving 16 trained lifters, full-depth (ATG) squats required greater perceived effort than parallel squats, but did not increase knee discomfort.
In fact, mild discomfort was slightly more common in the parallel condition. DOMS occurred more frequently after ATG squats, indicating greater muscular stress. Technique quality was comparable between squat depths.
These findings suggest that ATG squats are more physically demanding yet not more uncomfortable for the knees when performed with proper form and supervision. Coaches and athletes may incorporate ATG squats progressively to improve strength while monitoring recovery and soreness.

Keywords: ATG Squat: Ass to Grass, Parallel Squat, RPE: Rate of peceived exertion, DOMS: Delayed onset muscle soreness, knee discomfort, resistance training, trained lifters, technique assessment

Introduction

Brief background of the study (Powerlifting Perspective)

The squat is one of the three primary lifts in powerlifting and serves as a key indicator of lower-body strength, stability, and technical proficiency. In competitive powerlifting, lifters must achieve a hip crease below the top of the knee (ATG),also in training environments, many athletes perform full-depth or “ass-to-grass” (ATG) squats to maximize range of motion and muscle recruitment as full ROM directly stimulates muscle hypertrophy and increases neural motor recruitment (neural adaptation).

While deeper squats are believed to enhance quadriceps and gluteal development, they may increase compressive and shear forces at the knee joint, potentially influencing discomfort and recovery. Parallel squats, on the other hand, reflect less depth but may engage slightly different muscle activation patterns and produce distinct perceptual and recovery responses.

Gap in Current Research

Previous biomechanical research has largely focused on comparing muscle activation and joint kinetics across squat depths; however, very few studies have assessed subjective

responses such as knee discomfort, perceived exertion (RPE), and DOMS, especially among trained or competitive power lifters.

Moreover, most existing data emphasize performance metrics rather than how different depths affect lifters' comfort, technique consistency, and recovery factors that can significantly influence long-term training adherence and competitive readiness.

Hence, there is a clear need to investigate how ATG and parallel squats differ not just biomechanically, but also in terms of perceptual and recovery outcomes in experienced strength-trained individuals.

Aim or hypothesis of the study (Powerlifting-Oriented)

- **Aim:** To compare the effects of full-depth (ATG) and parallel squats on knee discomfort, perceived exertion (RPE), technique rating, and delayed-onset muscle soreness (DOMS) in trained lifters with a powerlifting background.
- **Hypothesis:** Full depth squats will demonstrate greater activation of the stabilizing musculature surrounding the knee and hip (e.g., gluteus maximus, all of four quadriceps, hamstrings) and induce a 'resting phase' at the bottom of the movement, thereby reducing peak reactive forces on the passive structures (ligaments and tendons) of the knee joint compared to parallel squats".

1) Injury Risk: In a parallel squat, the moment arm (the leverage) around the knee joint remains high at the bottom position. This creates high shear and compressive forces. Since the muscles are often not at an optimal length to produce force in this position, more of this stress is transferred to the passive structures the Anterior Cruciate Ligament (ACL), Posterior Cruciate Ligament (PCL), and patellar tendon.

The deep squat allows for a posterior shift of the torso (greater hip flexion), which transfers more load to the powerful hip extensors (glutes and hamstrings). This "unloads" the knee, protecting its passive structures.

My Point: Parallel squats put more stress on ligaments and tendons

2) Muscle Activation and Neuromuscular Benefits: This is well-supported by EMG (electromyography) studies.

- **Gluteus Maximus:** Activation increases significantly with deeper squat depths. Strong glutes are crucial for hip stability, which in turn stabilizes the entire kinetic chain and protects the knee.
- **Hamstrings:** Deep squats co-activate the hamstrings to a greater degree. This co-activation counteracts the pull of the quadriceps on the tibia, providing dynamic stability to the knee and reducing strain on the ACL.
- **Vastus Medialis (VMO):** Full range of motion is critical for comprehensive quadriceps development, including the VMO, which is essential for patellar tracking and knee health.
- **My Point:** Full depth squats provide more muscle activation.

3) Resting Phase and Force Distribution

This is a key observation. At the bottom of a full depth squat (with proper technique), the pelvis tilts posteriorly ("butt wink" in a controlled manner) and the hip musculature is fully stretched. In this deep flexed position, there is a brief period where the elastic energy stored in the muscles and tendons can be utilized for the ascent (concentric contraction of quadriceps femoris). More importantly, the system reaches a "transition point" where the acceleration is low. This can reduce the high-frequency, "jarring" reactive forces that are more prevalent when you abruptly stop the descent in a parallel squat and immediately reverse direction.

My Point: There is a resting period in the deep squat, making forces less reactive

Review of Literature

Summary of Previous Literature

Hartmann *et al*. (2020) [6] conducted a scoping review titled "Impact of the deep squat on articular knee joint structures: friend or enemy?" to evaluate whether performing deep squats poses any risk to the knee joint. The authors analyzed a wide range of biomechanical and clinical studies assessing the effects of squat depth on cartilage, ligaments, and menisci. Their review concluded that, in healthy individuals with proper technique, deep squats do not increase the risk of knee injury and may even enhance joint stability and muscular balance. The study supports the notion that full-depth squats can be safely incorporated into strength training and powerlifting programs when performed under controlled conditions.

Schoenfeld *et al*. (2019) [7] conducted an experimental study titled "Effect of squat depth and barbell load on relative muscular effort in squatting" to examine how different squat depths and external loads influence muscular effort across major lower-limb muscles. Using electromyography (EMG) analysis, they assessed quadriceps, gluteus maximus, and hamstring activation at varying squat depths and intensities. The study found that deeper squats elicited significantly higher relative muscular effort in the quadriceps and gluteal muscles compared to partial squats, particularly at moderate to heavy loads. The authors concluded that greater depth enhances total lower-limb muscle engagement but also increases perceived exertion. This supports the present study's investigation of how full-depth (ATG) squats may produce higher effort and soreness responses compared to parallel squats in trained lifters.

What's already done in previous studies

Previous biomechanical and EMG-based studies (e.g., Schoenfeld *et al*., Hartmann *et al*.) [7] have compared muscle activation and performance outcomes between deep and partial squats. They concluded that deeper squats enhance quadriceps and gluteal activation and do not increase injury risk in healthy lifters.

What my study adds

However, these studies primarily focused on muscle activation and joint mechanics, not on subjective responses like knee discomfort, perceived exertion (RPE), and DOMS, which are highly relevant to power lifters. The present study adds by comparing both ATG and parallel squats under standardized conditions to analyze perceptual, comfort, and recovery outcomes in trained lifters.

Results

Variable	ATG Mean ± SD	Parallel ± SD	Interpretation
Perceived Effort (RPE)	6.25±1.48	3.72±1.59	ATG Higher
Knee Discomfort (VAS)	3.31±2.55	4.34±2.95	Parallel Slightly Higher
Technique Rating (1-5)	3.40±0.83	3.56±0.81	Similar

DOMS Results

- **DOMS after 24 hours:** Reported by 6 of 16 lifters (37.5%)
- **DOMS after 48 hours:** Same (37.5%)

Most DOMS-positive cases occurred after ATG squats

Summary

This study compared full-depth (ATG) and parallel squats in 16 trained lifters to assess effort, knee discomfort, technique, and muscle soreness (DOMS). ATG squats required significantly higher perceived effort but did not increase knee discomfort compared to parallel squats. Technique ratings were nearly identical for both depths, indicating consistent form. About one-third of participants reported DOMS after ATG squats, suggesting greater muscular stress. Overall, ATG squats are more demanding but safe for the knees when performed correctly and can be beneficial for strength development with proper recovery.

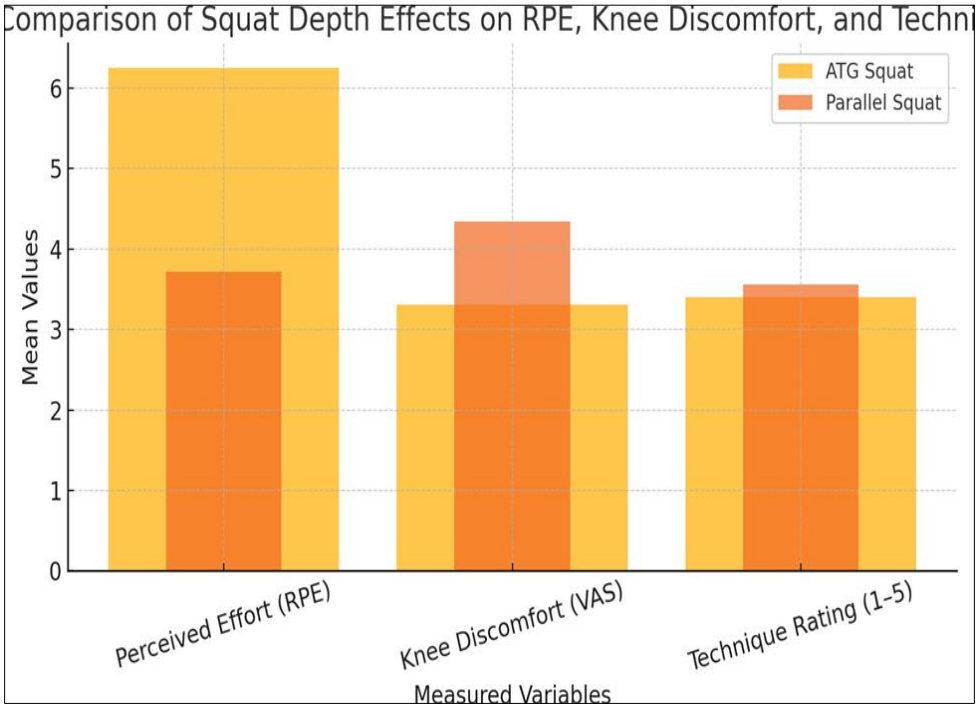

Fig 1: (Continuation): Comparison of squat depth effect

Discussion

Interpretation of Results

- **Perceived Effort (RPE):** ATG Squats had a mean RPE of 6.25, compared to 3.72 for parallel squats. This indicates that lifter felt ATG squats were considerably more demanding, likely due to greater range of motion and longer time under tension
- **Knee Discomfort (VAS):** Surprisingly, parallel squats showed slightly higher knee discomfort (4.34 vs 3.31). This suggest that knee stress is not solely determined by depth, proper technique can reduce discomfort even in deep squats.
- **DOMS (Delayed-Onset Muscle Soreness):** 37.5% of participants reported DOMS after ATG squats at 24h and 48h.Few or none reported DOMS after parallel squats, indicating greater muscular stress and microtrauma from deeper squats.

Summary

- **ATG squats:** Higher effort, more DOMS, but not more knee discomfort
- **Parallel squats:** Lower effort, slightly higher knee discomfort, less soreness.
- **Technique:** Comparable.

Comparision with Previous Studies

- Schoenfeld *et al.* (2019) [7] Effect of squat depth and load on relative muscular effort:
- Found deeper squats increased quadriceps and gluteal activation, supporting our finding of higher perceived effort and DOMS after ATG squats.
- Also observed that deeper squats can be performed safely when technique is maintained, aligning with our observation of similar technique ratings and no excessive knee discomfort.
- Hartmann *et al.* (2020) [6] Impact of the deep squat on articular knee joint structures.
- Concluded that full-depth squats do not inherently damage knee structures in healthy individuals, provided proper form is used.
- This aligns with our finding that knee discomfort was not higher in ATG squats, and slightly more reported in parallel squats

Takeaway
Both studies support our observation that ATG squats are safe and technically feasible, though they are more physically demanding and cause more muscle soreness.

Explanation of findings
- Higher effort in ATG squats.
- Greater range of motion → longer time under tension → higher neuromuscular demand.
- More muscle fibers recruited in quadriceps and glutes.
- Slightly higher knee discomfort in parallel squats.
- Possibly due to mechanical load distribution, where partial depth may concentrate stress on patellofemoral joint at a specific angle.
- ATG depth allows better load absorption by larger muscle groups.
- Higher DOMS in ATG squats:
- Deep squats involve eccentric lengthening of quadriceps and gluteal muscles → more micro trauma → soreness.
- Similar technique ratings.
- Supervision, warm-up, and trained lifters' experience minimized form breakdown despite greater depth.

Strengths and limitations of study
Strengths
- Experimental design with direct comparison of two squat depths.
- Standardized squat sessions → good internal validity.
- Practical relevance for power lifters and strength athletes.
- Use of multiple outcome measures: RPE, VAS, DOMS, technique ratings.

Limitations
- Small sample (N=16) → limits generalizability.
- Subjective measures (RPE, VAS, DOMS) → potential personal bias.
- Short follow-up (48h) → cannot capture long-term recovery or adaptation.
- Gender imbalance → mostly male participants.
- Technique rated by observation, not motion capture → less precise than biomechanical analysis.

Conclusion
Concise statement summarizing main findings
In trained lifters, full-depth (ATG) squats required greater perceived effort and led to more post-exercise muscle soreness (DOMS) compared to parallel squats, while knee discomfort remained similar or slightly higher in parallel squats. Technique quality was comparable between the two depths, suggesting that ATG squats can be performed safely with proper supervision and form.

Possible Clinical Relevance & Future Research Scope
Clinical/Sports Relevance
- ATG squats can be incorporated progressively in strength training and powerlifting programs to maximize lower-limb muscular activation and performance without increasing knee discomfort.
- Monitoring DOMS and recovery is important for training programming, particularly for athletes returning from lower-limb injury.
- Coaches and physiotherapists can use findings to individualize squat depth based on trainee comfort, effort tolerance, and recovery capacity.

Future Research Scope
- Include larger and more diverse samples (different ages, genders, experience levels).
- Investigate long-term adaptations: Strength, hypertrophy, joint health, and injury risk.
- Use objective biomechanical measurements (motion analysis, force plates, EMG) to correlate perceptual data (RPE, DOMS, discomfort) with joint loading and muscle activation.
- Explore effects of different loads (light, moderate, and heavy) and training frequency on perceived effort, DOMS, and knee health.

References
1. National Strength and conditioning association (NSCA). Essentials of strength training and conditioning. 4th Ed. Champaign (IL): Human Kinetics.
2. McGinnis P. Biomechanics of Sport and Exercise. 4th Ed. Champaign (IL): Human Kinetics.
3. Khan K, Maffulli N. Physiotherapy in Sport: Applied Science and Practice.
4. Brukner P, Khan K. Clinical Sports Medicine. 5th ed. Sydney: McGraw-Hill Education.
5. Delavier F. Strength Training Anatomy. 3rd Ed. Champaign (IL): Human Kinetics.
6. Hartmann H, Wirth K, Keiner M, Mickel C, Sander A, Szilvas E. Strength training for muscle strength, hypertrophy and power: A systematic review and meta-analysis. J Strength Cond Res. 2020;34(2):548-59.
7. Schoenfeld BJ, Ogborn D, Krieger JW. Effects of resistance training frequency on measures of muscle hypertrophy: A systematic review and meta-analysis. Sports Med. 2019;49(3):431-38.