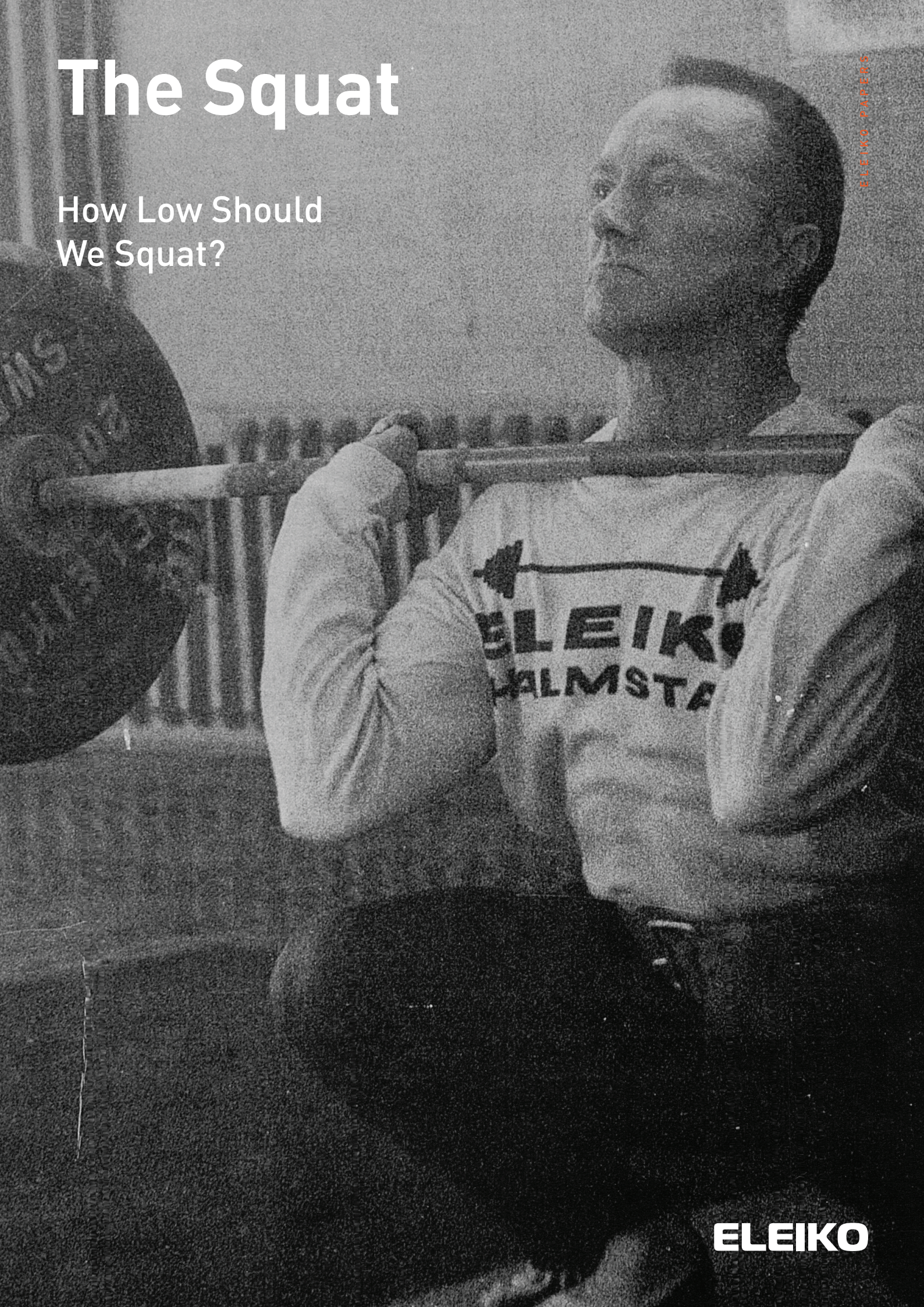
The Squat

How Low Should We Squat?



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The Squat

Abstract

Squatting is arguably one of the most vital actions we perform as humans and has, therefore, become one of the most commonly used exercises in strength training programs. The squat is really a total-body action (movement pattern) that involves relatively equal movement contributions at the ankle, knee, and hip. The squat is also an exercise that helps develop numerous neurophysiological benefits for better performance in both sports and in life. The ongoing question that still resides in the strength-training arena is centered around how low should we squat to best achieve these benefits?

How Low Should We Squat?

Figure 1. Overhead Squat

Figure 2. Front Squat

Figure 3. Back Squat

Squatting is arguably one of the most vital actions we perform as humans. As such, it has become one of the most widely used exercises within strength-training programs of all types – weightlifting, powerlifting, functional training, performance, and bodybuilding. The squat requires the predominant synergistic motion of the ankle, knee, and hip joints. A typical squat involves moving from a standing position to a sitting position and returning to a standing position, or even vice versa.

The squatting motion is also found in many movements we frequently perform in life and performance such as walking, running, lunging, stepping up/down (climbing stairs), jumping and more. Squats are also a vital component within the sports of Olympic Weightlifting and Powerlifting. In Olympic Weightlifting, the overhead squat is necessary to perform the Snatch (Figure 1), and the front squat is necessary to perform the Clean and Jerk (Figure 2). In the sport of Powerlifting, the back squat (Figure 3) is one of the three lifts performed with the other two lifts being the bench press and deadlift.

With squats being a fundamental aspect of our movement patterns, both in sport and life, they should be an essential part of our training programs to enhance activities of daily living and/or athletic performance. The benefits derived from squats are numerous. However, one of the biggest questions that still resides within the strength-training arena is centered around how low should we squat to best achieve these benefits?

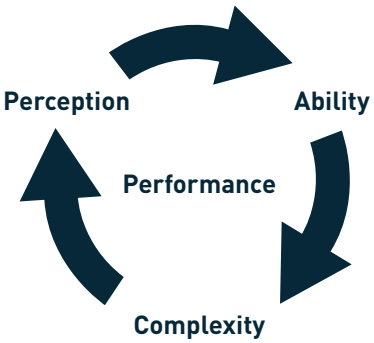
The remainder of this article will be dedicated to briefly exploring some of the research concerning the difference in performance gains between partial and full squats as well as touching on some safety concerns involved in full squats. The desired outcome of this article is to take all of this information and provide you with some practical recommendations for making a more informed choice about the squat depth best suited for your wants and needs.

Looking at Partial vs. Full Squats for Performance

A question many people ask is, "do partial squats or full squats work better for increasing performance such as jumping and sprinting?" Both depths have been shown to be beneficial (Pallarés et al., 2019; Vecchio, 2018; Rhea et al., 2016; Esformes & Bampouras, 2013; Hartmann et al., 2012; Chelly et al., 2009), but as is typical in research, there are contradictions between findings. It's important to keep in mind that these contradictions often arise as a result of the difference in how the studies are designed.

There are many factors that can dramatically influence the outcome of a research study. However, for our purposes here in this article, we'll focus on one main factor that we believe is, arguably, one of the most practical. This is the 'participants' being used in the study. More specifically, are they experienced or not with lifting and how proficient are they at the lifts being studied.

The reason we believe this factor is important is related to the Eleiko training and coaching principle of **Ability-Complexity-Perception.** This principle states that your **ability** should dictate the **complexity** of your training to produce a positive mental and physical **perception** about your training. In other words, what you are able to do should determine how much you do and/or how you progress so your mind and body are enhanced.



Think of it this way, when the complexity (or, challenge) of your training is within the scope of your ability level, you make positive changes both mentally and physically. You will feel a sense of achievement (mental) and produce a positive performance response (physical). Conversely, if the complexity of your training is outside your ability level (too low or too high), this can produce a less than optimal sense of achievement, or even a sense of failure, and lead to under or overtraining and/or increase risk of injury (Pallares et al., 2019). With this in mind, let's briefly explore a couple of the existing studies that have investigated the difference between partial vs. full squats using a prolonged periodised training programme of 10-weeks or more. What you will see is how the Eleiko Ability-Complexity-Perception training and coaching principle unfolds in the research.

Partial Squats

Partial squats are performed above parallel, or when the hip is higher than the knee. The rationale for using partial squats to enhance performance stems from the principle of specificity, or the SAID Principle (specific adaptation to imposed demands), which suggests using motions that have mechanical and force production similarities to the desired task (Zatsiorsky, & Kraemer, 2006). Jumping and sprinting techniques are usually rapid with a short eccentric loading phase, so partial squats would seemingly make sense.

There was only one good quality, prolonged programming study (16-weeks), which investigated partial vs. full squats, showing a favorable performance response for partial squats. Pay attention to the ability level of the participants.

Study: Rhea et al., (2016)

The authors looked at the how squats at 3 different depths – partial squats, full squat-parallel, or full squat-deep – would effect various performance measures including 1RM for each depth, vertical jump, and 40-yard sprint time.

This study used male collegiate athletes who were experienced and proficient at lifting - a minimum of 2 years of consistent year-round training and a minimum parallel squat 1RM of 1.5 times bodyweight.

The results showed:

- All 3 squat-depth groups improved their respective 1RM.
- The partial squat group had the largest effect and transfer to the vertical jump and 40-yard sprint.
- The full squat-parallel group had the second best effect and transfer.

Full Squats

Full squats are performed at or below parallel – hip parallel to or below the knee. The rationale for full squats can be derived from a number of studies, two of which were good quality, prolonged programming studies (10-weeks), which investigated partial vs. full squats, showing a favorable performance response for partial squats. Again, pay attention to the ability level of the participants.

Study 1: Hartmann et al., (2012)

The authors looked at how squats at 3 different depths – partial squats, full back squats (below parallel), or full front squats (below parallel) – would effect the development of 1RM in all 3 squats, a counter movement jump (CMJ), squat jump height, maximal voluntary contraction, and maximum rate of force development.

This study used male and female university students with low resistance training experience - full squat 1RM ranging between 0.87-1.15 times bodyweight

The results showed:

- The full back and full front squat groups showed significant improvements in all variables even an increase in the partial squat 1RM.
- The partial squat group made the biggest improvement in the partial squat 1RM, but the effects didn't transfer to any of the other variables.
- The partial squat group showed a lower post-test 1RM for both the full back and full front squats as well as the CMJ.

Study 2: Pallares et al., (2019)

The authors looked at how squat at 3 different depths – partial squat, full squat-parallel, and full squat-deep – would effect the development of 1RM and mean propulsive velocity (MPV) at each depth, Functional Performance – CMJ, 20-m sprint, and Wingate test – and Physical Disability – pain and stiffness.
This study used male university students with 6 months of training experience – full squat 1RM of ~1.17 times bodyweight.

The results showed:

- The full squat group was the only group that increased 1RM and MPV in all three squat variations and achieved the highest functional performance score – meaning best CMJ, 20-m sprint times, and best Wingate test results.
- The parallel squat group had the second best overall results.
- The partial squat group showed no improvements in neuromuscular and functional performance, and was the only group to have significant increases in pain, stiffness, and physical functional disability.

What Does This Mean?

To put it simple, they both demonstrated beneficial results for performance. Whether or not partial or full squats were beneficial was based upon the ability level of the participants. When the complexity (challenge of the training programme – load, volume, movements, etc.) was within their ability level, the results were positive. When the challenge was outside their ability level (whether too little or too great) the results were not as positive.

The participants with the higher ability level – minimum of 2-years consistent training and full 1RM > 1.5 times bodyweight – showed better performance gains from using partial squats in a periodised, total-body split routine strength training programme. They also showed benefit from full squats, just to a lesser degree (Rhea et al., 2016).

Potential rationale for these results may be due to the fact that partial squats can be / are typically performed at a much higher load than full squats (Rhea et al., 2016; Hartmann et al., 2012). It's suggested that being able to use heavier loads in similar patterns as the desired performance outcome (Principle of Specificity) may help evoke a heightened response in the leg extensors and lead to a reduction in neural inhibition of hip and knee extensors. This is further suggested to provide high transfer of force into the acceleration process of concentric and reactive speed-strength performance (Bloomfield et al., 2009). Athletes with higher ability have presumably achieved a relatively higher proficiency both mechanically and neuromuscularly, which may lead to a better result.

The participants with lower ability level – 0-6 months consistent training and full 1RM between 0.87-1.17 times bodyweight – showed better performance gains from using full squats in a periodised strength training programme. Though the programmes in these studies consisted of only squats over a 10-week period, it was probably a good thing to help control volume (complexity – mentally and physically) (Pallares et al., 2019; Hartmann et al., 2012).

Reasearch Summary

Participants with **higher** ability benefitted more from the use of **partial squats** in their training program, but also showed benefit from full squats to a lesser degree.

Participants with **lower** ability benefitted more from the use of **full squats** in their training program.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It is important to note that there are a number of studies that show benefits of partial squats for lower ability level participants (e.g. Chelly et al., 2009) and benefits of full squats for higher ability level participants (e.g. Esformes et al., 2013). The key to remember is that development of performance falls on a continuum. The equipment, positions, and actions being used should be based on the ability of the athlete/client and desired outcome. Benefits and progressions will occur differently for lower ability level athletes/clients than for higher ability levels (Haff & Nimphius, 2012).

Beyond the noted performance gains and, depending on the ability of the athletes, using full squats may also be a favorable choice to initiate gains in mobility. Strength training has also been shown to enhance mobility (Leite et al., 2017; Leite et al., 2015, Moraes et al., 2013; Todd et al., 2012; Morton et al., 2011). From a physiological standpoint, it would make sense that by increasing the range of motion of the loaded exercise, the ability of the limbs and joints to move with control through a greater range of motion would result (Todd et al., 2012; Morton et al., 2011).

Some Safety Concerns

Traditionally, there has been a concern that deeper squatting may have more harmful effects on passive structures such as increased risk of knee and/or low back/spine injuries.

First, it should be pointed out that research has shown weightlifters and powerlifters at various levels to have extremely low injury rates relative to other sports (Assa et al., 2017; Calhoon & Fry, 1999; Hamill, 1994). This is relevant because in these sports the use of full squats is necessary.

Looking at injury rates for weightlifters and powerlifters at various levels of competition, an injury rate per 1,000 hours of training in weightlifting was 2.4-3.3 (Assa et al., 2017; Calhoon & Fry, 1999) and an injury rate for powerlifters ranged between 1.0-4.4 (Assa et al., 2017). These numbers compare quite well to other sports noted – Track and Field 3.57, Alpine Skiing 1.17, American Football 9.6, Wrestling 5.7, Bodybuilding 0.24-1.0, Strongman 4.5-6.1, and Highland Games 7.5 (Assa et al., 2017; Keogh & Winwood, 2017).

In an earlier study looking at 1,634 weightlifters between 13-16 years old with over 168,000 hours of training, the authors concluded an injury rate of 0.0017 per 100 hours of training. These numbers also compare quite favorably to athletes of other sports – US Basketball players 0.03, US Track and Field 0.57, American Football players 0.10, and US Gymnasts 0.044 (Hamill, 1994).

Injury Incidence Per 100 Hours of Training

	Weightlifting	US Basketball	Track & Field	American Football	US Gymnastics
Injury Incidence	0.0017	0.03	0.57	0.10	0.044

Secondly, in a comprehensive review of literature, Hartmann et al., (2013) determined that an increased risk of injury with deep squats is not the case. In fact, the authors made the following conclusion:

> **"It is unclear why higher risk of injury of passive tissues in deep squats is hypothesized. When compared with half and quarter squats, in the deep squat, lower knee joint and spinal joint stress can be expected. Provided that the technique is learned accurately under expert supervision and with progressive training loads, the deep squat presents an effective training exercise for protection against injuries and strengthening of the lower extremity."**

Summary

Squats are one of our most vital movement patterns and should be an integral part of our training programmes. They have been shown to enhance a number of performance measures. Various squat depths have been investigated and shown to have differing effects on these performance measures. It appears that partial squats show more benefit for performance measures in higher ability level athletes/clients and full squats show more benefit for performance measures in lower ability level athlete/clients. It has also been shown that deep squats do not pose an increase risk of injury for the apparently healthy athlete/client.

Injury Incidence Per 1.000 Hours of Training

	Weightlifting	Powerlifting	Track & Field	Alpine Skiing	American Football	Wrestling	Body-Building	Strong-man	Highland Games
Injury Incidence	2.4-3.3	1.0-4.4	3.57	1.17	9.6	5.7	0.24-1.0	4.5-6.1	7.5

Recommendations

From all of the above information, we can suggest some recommendations. These recommendations are only a general guide. They follow the notion previously mentioned that enhancing performance happens on a continuum with benefits and progressions occurring differently for lower ability level athletes/clients than for those with higher ability levels (Haff & Nimphius, 2012). Furthermore, the complexity of training used should match the ability level for an optimal mental and physical response.

That said, there is no one size fits all recommendation. Personal preferences also play a major role as they will effect perception, and this can be important depending on the environment (home training vs. athletic strength and condition) and/or desired outcome (health and vitality vs. maximal performance).

When the ability level of the athlete/client is low – less than 12 months of experience and/or a 1RM less than 1.5 times bodyweight, research has shown that full squats may provide the better overall performance enhancing effects. This is not to say that partial squats cannot and should not be used!

As a recommendation, perhaps use full squats with lighter loads, slower tempos, and higher reps, focusing on control and alignment more so than partial squats. Remember, Ability-Complexity-Perception, personal/environmental preference, and desired outcome.

When the ability level of the athlete/client is moderate – 12-24 months of experience and/or a 1RM around 1.5 times bodyweight, the same basic recommendation applies only with increased loads and tempos and the use of partial squats may be implemented more equally. Again, remember Ability-Complexity-Perception, personal/environmental preference, and desired outcome.

When the ability level of the athlete/client is high – 24+ months of experience and/or a 1RM >1.5 times bodyweight, research has shown that partial squats may provide that added stimulus necessary to boost performance. This is not to say that full squats cannot and should not be used! As a recommendation, perhaps use partial squats at least as much, if not more, than full squats. And yes, once again remember Ability-Complexity-Perception, personal/environmental preference, and desired outcome.

Practical Recommendations For Squat Use and Performance

Weightlifting	Squat	Complexity	Benefit
Training age <12 months; 1RM < 1.5 x BW	FULL ⩾ PARTIAL	Slower, focus on alignment; control descent & transitions e.g. 50-80% effort @3121 for 10 reps > @2111 for 6-8 reps > @1010 for 5 reps	↑ mobility, total work, movement efficiency, soft tissue & joint resiliency, performance ↓risk of injury
*Training age 12-24 months; 1RM ~1.5 x BW	FULL ⩾ PARTIAL	Faster > explosive, focus on alignment; smooth transitions 70-90% effort Include deload / recovery!	↑ performance mobility, soft tissue & joint resiliency, total work, movement efficiency, ~ maintain mobility ↓ risk of injury
*Training age 24+ months; 1RM >1.5 x BW	PARTIAL ⩾ FULL	Explosive, alignment; smooth transitions 80-100% effort Include deload / recovery!	↑ performance, soft tissue & joint resiliency, total work, movement efficiency, ~ mobility, risk of injury

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