ANTHROPOMETRICAL CONSIDERATIONS FOR CUSTOMIZING THE SQUAT PATTERN

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DEBUNKING DEEPLY ROOTED SQUAT DOGMA

The squat has been one of the most debated topics across demographics in the fitness and sports performance industries for as long as people have been lifting weights. As the fitness industry continues maturing, so does the ability to answer some of these debated questions. In a constantly evolving industry that has experienced the golden age of bodybuilding in the 1970s, the rise of competitive powerlifting in the 1980s, and the exponential growth of Olympic-style lifting and CrossFit in recent years, the influences of these specialty barbell sports have influenced the way in which coaches, athletes, and general fitness consumers view the squat pattern as sport-specific requisites to achieve a desired goal.

As our industry continues to be exposed to more sport-specific squatting influences, we have lost an appreciation for the squat being a fundamental movement pattern present in the normalized human developmental sequence, and not an exercise that only occurs within the confines of the gym.

As we gain more insights into the unique anatomical, biomechanical, and neuromuscular variables between individuals, the need to customize a squat pattern according to an individual's specific needs instead of their theoretical sport or goal set has become apparent. If people are all built differently how could they all squat the same? It is time to throw away the one size fits all dogmatic approach to squatting. Outlined below is a method to help determine an individual's preferred squatting foot position, setup, and depth based on their unique hip anthropometrics for smarter, safer and more optimized squatting.

HIP VARIATION AND SQUATTING

Despite the various styles of squatting over the last several decades, individuality in anatomy has come to the forefront and should not be disregarded when it comes to optimizing the squat stance of an individual. The anatomical differences from person to person of the bony anatomy of the hip cannot be ignored when finding the best squat stance for the longevity of the athlete. The differences in hip anatomy will affect the ability of an athlete to squat in a certain stance.

The main considerations for bony anatomical variation of the hip are:

- Femoral version (the angle of the neck of the femur compared to the knee)
- Acetabular version and inclination (where the hip socket is pointing)
- Combined version of femoral neck and hip socket (summing the orientation of the hip socket and the femoral neck)
- Acetabular depth (depth of the hip socket)

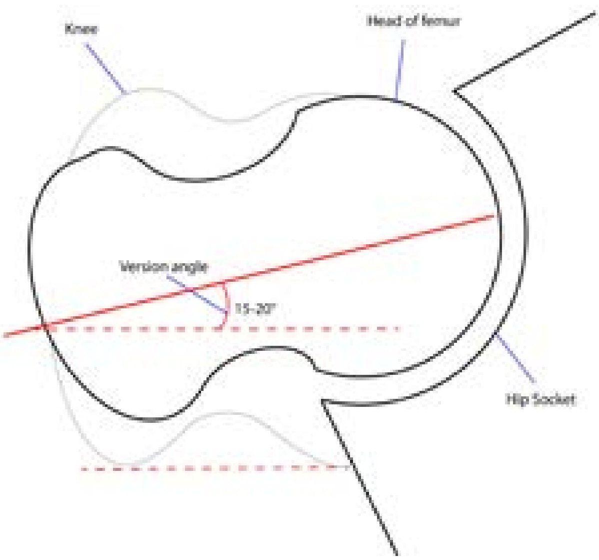
Since both the head of the femur and hip socket can have variations in version (forward/backward orientation), the sum version should be considered. The McKibbin Instability Index is used to sum the versions and may be predictive of hip issues with squatting (4).

The following images visually demonstrate the variations. Bone photos are courtesy of Paul Grilley.

WHAT IS FEMORAL VERSION?

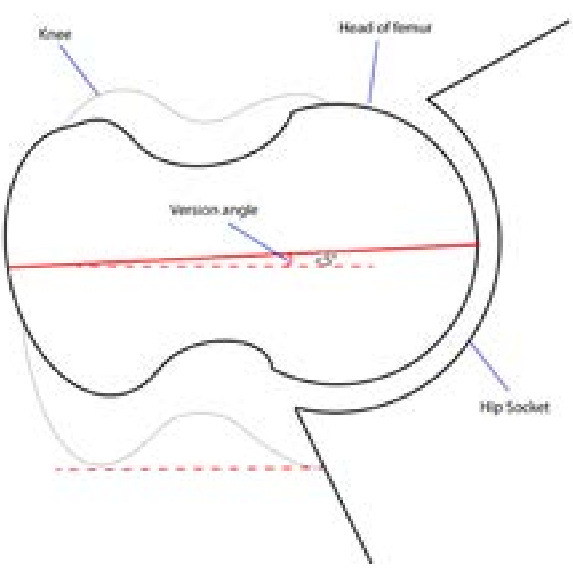
Version, or the orientation of the femoral head and neck to the knee, can vary. Normal femoral version is displayed in Figure 1, with the femoral head and neck oriented forward around 15 degrees.

FIGURE 1. NORMAL FEMORAL VERSION



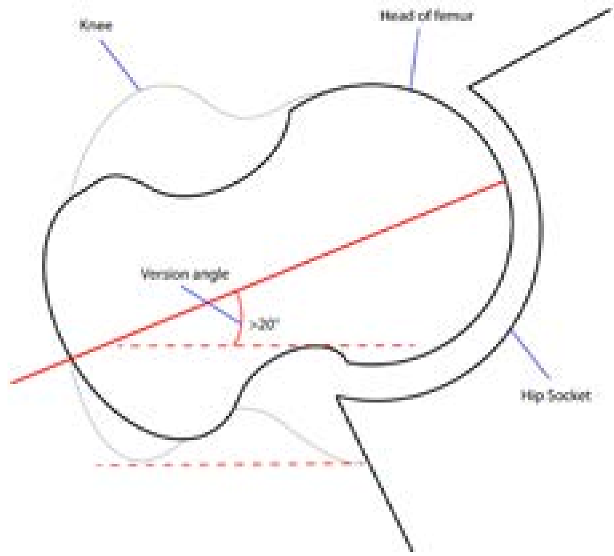
The average hip joint has version in this range with a forward orientation. Femoral retroversion is when the femoral head/neck are oriented backward from normal.

FIGURE 2. FEMORAL RETROVERSION



Note the small version angle. Typically a retroverted person needs to rotate their hip outward when squatting. Femoral anteversion is when the femoral head/neck oriented more forward from normal.

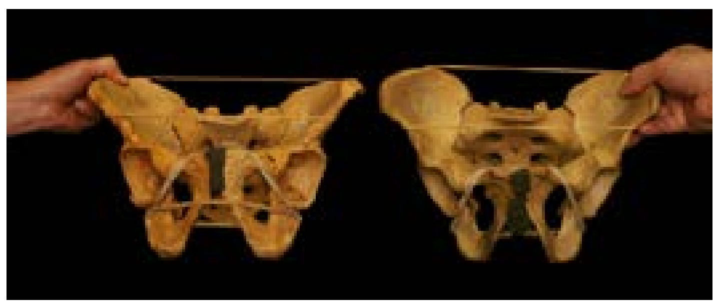
FIGURE 3. FEMORAL ANTEVERSION



Notice the large version angle. The head/neck of the femur are pointed more forward when compared to the angle of the knee. The more retroverted the femur, typically the more toed out squat stance is needed. The more anteverted the femur, the more toed forward squat stance is tolerated.

ANATOMICAL VARIATIONS – ACETABULUM

FIGURE 4. ACETABULAR ORIENTATION

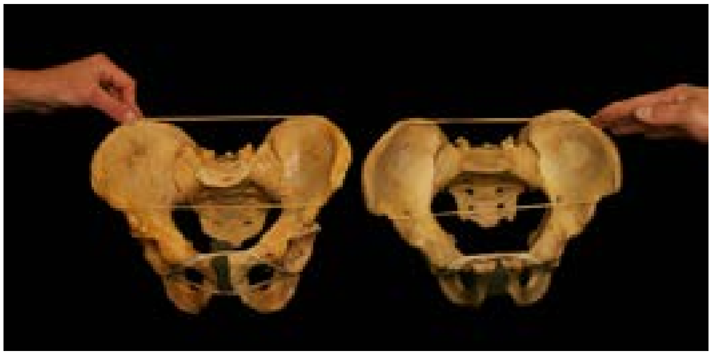


This photo illustrates a difference between the acetabulum orientation of two different hip joints. The specimen on the left has a more forward and upward orientation of the hip sockets. The specimen on the right has a more lateral and inferior orientation.

FIGURE 5. ACETABULAR VERSION

The specimen on the left demonstrates an acetabular orientation pointed more forward and downward compared to the specimen on the right.

FIGURE 6. ACETABULAR ORIENTATION COMPARISON



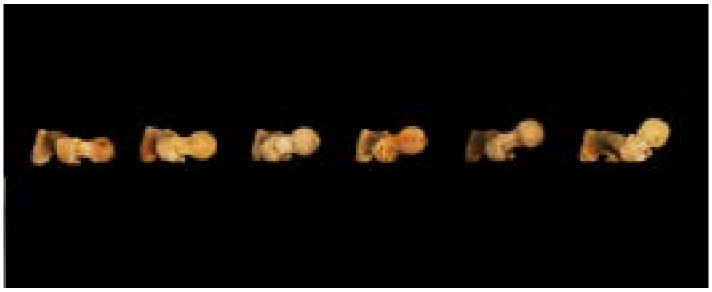
The specimen on the left has visible hip sockets due to their orientation. The specimen on the right has hip sockets oriented downward, which are not visible in this view.

ANATOMICAL VARIATIONS – FEMUR

FIGURE 7. SUPERIOR VIEW - FEMORAL VERSION

This figure is looking down the length of two left femurs. The femur on the left is retroverted and the femur on the right is anteverted. Both are left legs.

FIGURE 8. SUPERIOR VIEW - FEMORAL VERSION SPECTRUM



A spectrum of left femurs with the most retroverted femur on the left and the most anteverted femur on the right. All are left legs.

Version of the hip can vary by region of the world (3,12) and by gender (1,5). In one study, the average Caucasian male was shown to have seven degrees of anteversion (range -2 to 35 degrees) and the average Chinese male had 14 degrees of anteversion (range -4 to 36 degrees) (5).

In a study on femoral version in populations across ethnicities, Caucasian males were shown to have retroversion at a rate of 24.1%, African American males at a rate of 15.1%, and all ethnicities of females at 14.3% (6). With the known variations in hip morphology, an assessment is indicated to place people in the proper squat stance for their body.

FUNCTIONAL QUADRANT TESTING TO DETERMINE APPROPRIATE SQUAT STANCE

In order to objectively assess all unique variables of both the femur and acetabulum interplay as a functioning unit that can be scaled up with the squat pattern, a standard orthopedic assessment called the quadrant test, also known as the hip scour, test can be used (2). This test has been utilized for decades in orthopedic practice to manually assess and diagnose the presence and/or location of a hip labral tear, among other unique pathologies such as degeneration, femoral-acetabular impingement, and avascular necrosis of this region (10). The goal for administering this assessment is not to medically diagnose pain or dysfunction, but rather to use the key positions and properties which make this test extremely reliable to gain an appreciation for the femoral acetabular joint's shape, size, and movement capacity at the deepest joint level minus restrictions from local soft tissue structures.

Positioning your client down in the supine position allows full support of the spine and pelvis in a neutral position, which is of pivotal importance when testing in a reliable and repeatable manner. As with any standardized testing position, the presence of compensation patterns at any segment in the body other than that being tested can lead to false positives and unreliable data collection that can make it more difficult to reliably scale it up the squat pattern based on the key measurements taken. Ensure that the lower extremity on the testing side is the only aspect of the body moving to avoid compensations from the pelvis, spine, or opposite side extremity. From this position, degrees of hip flexion, external rotation, and abduction occurring synergistically will be tested in order to maximize a pain-free hip flexion angle which will represent the theoretical glass ceiling on squat depth that the hip joint itself is able to display with motor control taken out of the equation.

FIGURE 9. HIP QUADRANT TEST

By moving the hip in and out of these windows of motion with the leg reaching terminal knee to chest position with rotary planes also involved, centration of the hip joint can occur. Centration can be defined as maximizing the surface area contact of any joint, in this case, the femoral head into the acetabulum of the pelvis. Increased joint centration can increase the activation of intrinsic stabilizers of the region, and also allow optimal length tension relationship of some bigger secondary dynamic stabilizers, such as the gluteal and adductor group, in order to more optimally position for biomechanical success in the squat pattern. This also allows stronger neuromuscular recruitment and coordination of this compound movement pattern centered around the hip complex.

It is important to note that this assessment takes practice, repetitions, and experience to reliably administer, especially for the goals of grading it up into the squat pattern. Also, it is important to ensure that you are gaining verbal and non-verbal communication and feedback from your client on how these altered positions of the hip feel to them, as pain is never a normal response and can be used to identify red flags for medical referral when necessary. Once optimal hip position on one side of the body is determined, cue your client to hold their knee in that position while you repeat the assessment for the opposite side. Once both hips have been assessed and your client is holding both in place with cues such as "glutes flexing" and "toes up," it is time to take measurements and record your data.

The four measurements are:

1. Buttocks-to-floor distance
2. Distance between knee caps from mid-patellar line
3. Foot abduction angle from foot's midline
4. Distance between heels at mid-calcaneal line

Utilizing this data, especially the mid-calcaneal foot width and the foot abduction (toe out) angle, we can scale this squat setup into the standing position starting with these measurements. Note that the mid-patellar width and the buttocks-to-floor distance may not be instantly translated into the standing position due to a lack of motor control skill set in this new stance. This will be the time to coach around these positions with the goal of reaching the theoretical buttocks-to-floor distance and knee cap width distance at terminal authentic end range of motion.

FIGURE 10. BILATERAL QUADRANT TEST

In this figure, the four key measurements taken from the bilateral quadrant test position setup are showcased with the red line indicating the measurement taken referenced above.

It is not expected, nor normal to have clients hop right from the table to a standing squat and be able to execute it pristinely. Due to motor control gaps in the mobility-stability continuum centered around the squat pattern, this will be something that will need to be targeted and improved over time, but now with an objective measure of someone's bony anthropometrical capacity.

SIMPLE APPLICABILITY OF SQUAT STANCE CUSTOMIZATION

Given the results of the quadrant tests previously described, there are two main variables that can be altered in a squat stance to maximize athlete comfort, depth, and proper execution of the exercise. The first variable in squat stance is width.

After evaluating with the quadrant test, you will find that maximal hip flexion is achieved in some amount of hip abduction vs. adduction before lumbar flexion occurs, which correlates to the mid-patellar distance and distance between heels at the mid-calcaneal line. If maximal hip flexion is achieved with relatively more hip abduction, a wider squat stance may be more ideal for that athlete, depending on other factors, such as limb length, torso length, and ankle dorsiflexion range of motion (9). If ankle mobility is limited, a wider stance may be necessary to prevent the center of mass from being too far behind the base of support (8).

The second variable in stance is degree of toe out or external rotation at the hip joint. When performing the quadrant test, maximal comfortable hip flexion will be achieved for different athletes at a variety of angles of external rotation due to the anatomical variations outlined previously in this article. This will be identified as the foot abduction angle, which was measured during the hip quadrant test, representing the amount of "toe out" angle in the setup of the squat pattern.

FIGURE 11. NARROW VS. WIDE STANCE

In Figure 11, the squat stance on the left showcases a narrower foot width position compared to the wider foot width position on the right as measured by the mid-calcaneal line measurement between heels.

FIGURE 12. FOOT ABDUCTION ANGLES

In Figure 12, the left side squat stance shows an increased foot abduction angle or "toed out" position, while the right shows a more neutral foot abduction angle or "toe in" position.

FIGURE 13. COMMON SQUAT STANCES

Figure 13 displays four avatar positions for possible manipulation of squat stance based on anthropometrical considerations. Each of these squat stances are examples of starting points to position your athletes in sound starting stances, but the use of the quadrant test for more objective and customized measures is encouraged.

1. Narrow foot width with minimal foot abduction angle
2. Narrow foot width with increased foot abduction angle
3. Wide foot width with minimal foot abduction angle
4. Wide foot stance with increased foot abduction angle

Generally, the more retroverted an athlete's hips, the more toe out they will need to be in the squat, and the more external rotation they will have during the quadrant test to achieve maximal flexion. You will see this as an increased foot abduction angle. For an athlete with more anteverted hips, a relatively more toed forward stance may work better for them (depending on other anatomical variables) in the squat. They will also likely need less hip external rotation to achieve maximal flexion in the quadrant test. You will see this as less foot abduction angle. Testing a combination of stance widths with varying angles of toe out is the best method to determine optimal squat stance after performing the quadrant test, starting with the stance determined by the data acquired in the quadrant test.

CONCLUSION

Begin with the stance identified by the quadrant test. Have your client perform a squat. Repeat with a slightly wider stance with the same amount of toe out. After performing variations in width, check different degrees of toe out at different widths until you find the combination of both variables that allows the athlete the best squatting depth with the least compensations to the squatting pattern. This optimal squat stance will likely be similar to the measurements acquired in the quadrant test, but may differ due to stability and motor control issues, ankle dorsiflexion limitations, and leg length. Ultimately, it is recommended that athlete comfort dictates the combination of width and toe out taken in the squat stance, as long as known biomechanical faults (knees collapsing in, lumbar flexion, heels elevating) are not present (7).

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John Rusin is a sports performance coach and injury prevention specialist who has worked with some of the most elite athletes in the world, including multiple Olympic medalist, National Football League (NFL) and Major League Baseball (MLB) All-Stars, world record holding powerlifters, International Federation of Bodybuilding and Fitness (IFBB) bodybuilders, and All-World IronMan triathletes. Rusin's pain-free performance training systems are used by thousands of coaches, trainers, and rehabilitation professionals from across the world to help optimize athletic performance and physical longevity. In the last three years, Rusin has coached more than 10,000 clients through his best-selling book, "Functional Hypertrophy Training."

Ryan DeBell is a sports chiropractor and has a Master's degree in Sport and Exercise Science. He graduated Summa Cum Laude from the University of Western States. Before becoming a chiropractor, DeBell attended the University of Washington's Foster School of Business, where he graduated Magna Cum Laude with a Bachelor's degree in Business, focusing on management of information systems. DeBell is a member of Beta Gamma Sigma, the international honor society for business, which is the highest recognition a business student can achieve in a business program. Additionally, he is a member of Phi Beta Kappa, the most prestigious academic honor society in the United States. After graduating from the University of Western States, DeBell started Movement Fix and has travelled internationally speaking about health and fitness.