Technique

Introduction

Biomechanics is an integral part of exercise technique. Nevertheless, trainers and coaches dismiss using biomechanics to its fullest extent because of the amount of information involved especially the mathematics. Many believe they must spend hours learning complex mathematical procedures to show how much weight one can lift or just performing a movement better. Applied biomechanics is the most useful for coaches and lifters. They can use the applied concepts immediately (biomechanical principles) and only need to use the mathematics to identify specifics for a certain point of any movement. The following statements sums up the necessity of using biomechanics in teaching exercise:

“There is no point telling a lifter to perform a certain type of training if the coach/trainer does not understand how much force the lifter/trainee must produce, in what direction, over what range of motion, and at what speed. Instead of spending months giving an already seasoned lifter/trainee more work volume to make them just a bit fitter, a coach/trainer can spend a few weeks altering their lifting technique to make them staggeringly more efficient. Doing this justifies using biomechanics to substantially improve strength for any performance.”

Observing and Analyzing Exercise Techniques

For every exercise, someone somewhere will tell you how an exercise should be performed. You must ask yourself “is this really the proper way to perform this movement?” as well as “is there any real evidence this way of doing this exercise is correct?” When looking for how to do any exercise/movement every coach, trainer, or anyone who has performed that movement is an expert on how “they” believe a particular movement should be performed. Please note all coaches have some insight to performing a movement correctly based on experience and a base of knowledge pertaining to how to coach a movement. Our point here is there might be additional information on optimizing mechanics.

Where do you start? Let us review information which gives insight on how to evaluate a movement or exercise followed by description movement techniques for essential exercises in a strength training program.

Understanding the Nature of Skills

• Any movement pattern (squat, deadlift, walking, running, throwing) is a general series of anatomical movements that have common elements of spatial configuration, such as segmental movements occurring in the same plane of motion (refer to the chapter on Biomechanics).

• These general movements are not limited by any external influence assuming that the performer is able to execute them unimpaired.

• When a general movement pattern (normal human movement) is adapted to the constraints of a particular task or sport, it is called a skill. An example is a deadlift or squat within the general pattern of lifting.

When a particular type of the same skill or task is performed, it is called technique. Example: Two techniques used in the deadlift are the conventional and sumo deadlift. Different segmental movements are used to perform these types of exercises, and each technique is recognized by the series of segmental movements used to perform it. Within each technique, a performer may use individualized modifications such as unique timing, specialized movements, and/or individual positions (stance width, hand position, etc.). These individualized adaptations of a technique are defined as individualized style of technique or performance. Styles of technique or performance are dictated many times by the length of body segments in relation to the movement environment. Body segment lengths vary depending on one’s body type and are considered one type of human constraint dictating a particular technique is used. Additional human constraints include muscular strength, power output capabilities, endurance, flexibility, and motor/skill learning capabilities (Kreighbaum and Barthels, 4th Edition, 1996). Please note that the previous constraints are all considered to be categories of strength. Another variable to optimize technique is studying joint structure to learn the movement variables of each type of joint. Another consideration is joint/bone formation. Humans have the same parts; however, how each joint or bone is shaped varies considerably and can substantially vary joint movement if not identified. Identification of these variables gives the coach/trainee considerably more information and insight to optimize mechanics to improve performance and decrease the risk of injury.

Goal of Biomechanics

As previously stated, the goal of biomechanics is

• Increase performance

• Decrease injury

To reach goals, previous knowledge to identify physical limitations (strength deficits) must be used to eliminate them through physical training. As stated in a previous chapter, our sport is overcome with Analysis Paralysis! This means:

• Paralysis comes from too many experts

• Paralysis comes from too many systems of training

Few in the sport of Powerlifting perform both qualitative and quantitative technique analysis. Too often we see “Do this technique but don’t focus on eliminating the deficits – just copy this training program and it will solve your problems.” Biomechanics and physical training must be blended together. This blending facilitates development
of individual styles of technique for all movements as well as an individualized approach to training.

- The fundamental principle of training called the “S.A.I.D. Principle” - “specific adaptations to the imposed demands”

- This concept is not new – it has been around for decades. This concept states:
  - Theoretically MOST exercises and drills must be specific to the sport or activity.
  - If the exercises and drills you use in training closely match the aspects of the skill you are training for, you will have greater gains in performance.
  - For some sports or activities, the type of training that is specific to the sport or activity is obvious.

Is this always true? The answer is no! In other cases, the training exercises that are specific to the sport or activity may not be as obvious especially using accessory/supplemental movements under load to supplement the specific movement. This is called “Dynamic Correspondence”

The specific strengths needed to be successful in any activity are not obvious to the casual observer. When designing a training program one must ask numerous questions for using the appropriate analysis to teach each movement:

- What muscle groups are involved in the movement to include origins and insertions?
- What bones and joints are involved?
- What are the segmental movements?
- What are the angular velocities at each joint involved?
- What forces (external versus internal) are necessary to cause movements?
- What is the fiber arrangement of the muscles and their capability to produce force?
- What is the muscle’s angle/line of pull on the bone to cause a movement (greater than or less than 90°)?
- What is static and/or dynamic within the movement?
- What type of motion is involved?
- What is the Plane of motion?
- What Type(s) of strength are involved in the movement? - There are multiple categories of strength specific to the motion or activity
- This is covered in the Program Design chapter

Fig 1 See: “Multiple Categories of Strength” on page 194.

All the previous information covered must be used appropriately:

- Biomechanical principles
  - Kinematics (Motion)
    - Types of motion
    - Acceleration, velocity, displacement/distance
  - Kinetics (Forces)
    - GRF, RFD, external versus internal, linear versus rotary, base of support (area of the BOS)
    - Goals for technique, training, or doing activities
    - Determination of what type of activity
    - OPO for each activity (Overall Performance Objective)
    - Every activity involves basic human movements
    - HM (human movement) applied to ANY activity is a SKILL
    - Every SKILL has a technique
  - Numerous variations of a particular skill
    - New variation of a skill involves variation of a particular presentation of technique
    - Constraints to any technique
      - Somatotype (body type), joint/bone formation, and ROM all which dictate their individualized STYLE of technique.
Biomechanics and Training

Now we can associate these two terms (biomechanics and training) more closely together. Two specific categories are involved: Technical and Tactical

- **Technical**
  - Structure and Function
  - Kinesiology (study of movement)
  - Rigid body mechanics
    - Statics
    - Dynamics
  - Kinetics and Kinematics

- **Physical** (tactical)
  - Various types of strength training

Technical Training

The proportion of time allocated to technical training depends in part on the technical difficulty of the activity. **Do not** underestimate this step! What should be done first to ensure technical training is done correctly?

1st - perform a qualitative and quantitative postural, ROM, and bone formation analysis to collect specific data

2nd - Determine the skill to be performed

3rd - demonstration of the correct technique

4th - observation of the person desiring to perform said movement

5th - evaluation of said movement

6th - instruct performer on how to correct any flaws in said motion

- If flaws in said motion cannot be corrected then any deficit must be identified and a plan must be put in place to eliminate said deficit accordingly
- What variables are affecting the skill? (specifically body type)

Listed below are additional factors involved with “technical training”

- Type of skill (discrete or non-discrete/open or closed skill)

- Phases of the movement
  - Preparation Phase (set up)
  - Execution Phase
  - Descent, transition, ascent
  - Recovery Phase
    - Single rep, multiple reps

- Additional drills to reinforce the skill (tread cautiously here)
- Examine the drills and exercises used in the technical training for an activity you are familiar with.
  - What is the purpose of the drill or exercise?
  - What aspect of the skill is it specific to?
  - Are the joint positions, velocities, and ranges of motion of the exercise similar to those of the skill?
  - Are the muscle forces and contraction velocities similar?
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- The drill/supplemental movement do NOT have to be exactly the same to transfer to the primary skill (This is called Dynamic Correspondence)
  - Are the external forces similar?

Please note: performing various drills can be considered advanced training. Additional drills can be classified as instructional or performance enhancement!!!

Muscle forces, contraction velocities, and magnitudes of external forces are difficult to assess qualitatively, but coaches can view the joint positions and ranges of motion to assess joint angular velocities.

Quantitative biomechanical analyses of exercises and drills for specific sport skills would be more valuable, but few have been reported in the biomechanical literature.

**Bottom Line: if you want to become efficient at a skill you MUST practice it!!!**

The use of supporting strength training movements may enhance performance, but only after a substantial period of time dedicated to learning a movement pattern efficiently and effectively to develop each lifter’s individual style of technique.

**Physical Training**

Physical training is directed at altering performance limitations of the performer. Be aware that there is usually some overlap between the two types of training. Technical training may have some effect on the performer’s physical condition, and physical training may have some effect on the performer’s technical proficiency.

Biomechanics is directed at improving movement proficiency of physical training. A biomechanical analysis of an activity can identify the specific muscle groups whose strength, power, endurance, or flexibility limits performance. Specific exercises can then be chosen to strengthen and/or improve mobility in these specific muscle groups and connective tissues. Likewise, a biomechanical analysis of an exercise can identify if the muscles used in the exercise are those used in the sport or activity.

**Qualitative Anatomical Analysis Method**

The purpose of a qualitative anatomical analysis is to determine the predominant muscular activity during specific phases of a performance and to identify an “instance” where large stresses may occur due to large muscle forces and/or extremes in joint range of motion.

RED Arrow: if joint is less than 90 degrees it is a stabilizing force (it states 113.5 since our reference is 180 degrees when leg is straight. If the straight leg is referenced at 0.0 degrees, the knee is considered at 66.5 degrees and less than 90 degrees). Stabilizing force is always perpendicular to the line of muscle force.

ORANGE Arrow: this is the rotary component/vector to dictate the rotation force of this system

GREEN Arrow: this is the actual line of pull/force of the muscle.

Identification of the predominant muscles used, the large stresses involved from large muscle forces, and joint ROM

The teacher or coach may complete such an analysis on a novice trainee or on an elite performer. The analysis of the elite performance identifies if the muscles involved in a specific performance are used in the correct manner to elicit the most effective technique. The analysis of the novice trainee identifies any deficiencies in a particular movement as well as the muscles used. In either case, the methods used to identify the muscles involved and proper technique are the same for both novice and elite.

**Methodologies to determine Muscle Activity**

The following are standard methods for determining if the movement used is targeting the correct muscle/muscle groups.

- Palpation
  - Useful in slow, deliberate movements

- Participation
  - Muscle soreness

- EMG

- Video Analysis
  - Numerous Systems

- Visual Analysis
  - The coach must “see” all the forces involved both internal and external.
Cost will dictate in-depth analysis; however, the only unreasonable methodology listed above is EMG which can be costly. Video analysis is becoming very affordable with numerous systems available to coaches. While these methodologies are valuable, both coach and lifter must have the ability to visually analyze and “feel” if the movement is performed correctly. Both coach and lifter should participate in performing movements to understand and “feel” what a good performance is as well as see all the forces (as stated above).

**Standard Anatomical Analysis Steps**

**Guidelines for performing a quality movement analysis:**

1. Divide the activity into temporal phases (specific phases of time).
2. Identify the joints involved and the movements occurring at those joints.
3. Determine the type of muscular action (concentric, eccentric, or isometric) and identify the predominant active muscle group(s) at each joint.
4. Identify instances when rapid joint angular accelerations (rapid speeding up or slowing down of joint motions) occur and where impacts occur.
5. Identify any extremes in joint ranges of motion.

**For Temporal:**

- Breaking down each movement into specific phases
  - Preparation, execution, recovery
  - Each step may have multiple steps based on speed of movement (slow, medium, fast)

- Basic or simple movements (Slower)
  - Bench press, squat, deadlift
  - Note: these movements are not always slow!
  - Visual analysis effective (phase by phase)

- Complex Movements (Fast)
  - Snatch, Clean & Jerk, Jumping, Speed Squats/Benches/Deadlifts
  - Video analysis to slow motion down advisable when advancing to higher level of achievement to track smaller technique flaws (frame by frame)

**For Joints:**

Once the performance has been broken down into specific phases or recorded on video, the next step is to identify which body segments and joints to examine.

- Which segments and joints are involved in the performance of the skill?
- Which segments move, and which joints are involved in the movements?
- For skills involving gross movement of the whole body, most of the major joints are involved.

Also pertaining to joints and motion you must ask:

- What is the joint motion?
- What is the plane of motion?
- Single joint or multi-joint motion?
- Is the motion Ground-based and multi-planer?

**Muscle Actions and Active Muscle Groups:**

- Determine what types of muscle actions occur within the active muscle groups crossing each joint and to identify these active muscle groups
  - Dynamic (primary, secondary)
    - Concentric (myometric or muscle shortening)
    - Eccentric (pliometric i.e. plyometric or muscle lengthening)
  - Static
    - Isometric/stabilizing

**Forces (anything that causes or tends to cause a change in motion; F = ma)**

- Types of force
  - External/Internal
  - Linear/Rotary
  - Stress/Strain
    - Compression
    - Tensile
    - Torsion
    - Shear

**Remember: All resistance training is considered ‘force training’**

You must also consider:

- Rapid Joint Angular Accelerations and Impact Forces
  - Mostly during fast/explosive movements
  - Does occur during slower movements as well (Maximum Strength/Force Training)
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- Fast: Olympic Weightlifting and Speed Squats/Bench/Deadlift

- During concentric and eccentric actions
  - Initial fast applied force to an object is acceleration but the object being accelerated wants to decelerate
  - When you are moving an object then slow down it is decelerating the movement of the object but the object wants to accelerate downward

Extreme Joint Ranges of Motion

Identifying any extremes in joint range of motion is the final step in a qualitative analysis. The purpose of this step is to identify those muscles and soft tissues that may be stretched beyond capacity and possibly injured. Flexibility exercises may be appropriate for these muscle groups. As with the previous step, this step is more important when we are analyzing fast movements.

An example of charting a qualitative analysis

<table>
<thead>
<tr>
<th>Joint</th>
<th>Phase of motion</th>
<th>Joint motion muscle contraction</th>
<th>Active muscle group</th>
<th>Rapid acceleration or impact</th>
<th>Extreme range of motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow</td>
<td>Down</td>
<td>Flexion</td>
<td>Extensors</td>
<td>At end of phase</td>
<td>Full flexion at end of phase</td>
</tr>
<tr>
<td></td>
<td>Up</td>
<td>Extension</td>
<td>Extensors</td>
<td>At beginning of phase</td>
<td></td>
</tr>
<tr>
<td>Shoulder</td>
<td>Down</td>
<td>Horizontal extension</td>
<td>Horizontal flexors</td>
<td>At end of phase</td>
<td>Full horizontal extension at end of phase</td>
</tr>
<tr>
<td></td>
<td>Up</td>
<td>Horizontal flexion</td>
<td>Horizontal flexors</td>
<td>At beginning of phase</td>
<td></td>
</tr>
</tbody>
</table>

Movement Evaluation Guidelines

How must a coach and lifter put everything previously learned together to determine what proper techniques in the three main Powerlifting movements look like? These next steps utilize all the previous information acquired within this manual especially in the introduction!! . In other words, this is the culmination of all prior information combined. They are also to “reinforce, support, and cement” the “Do I principles” for all movement/motion.

These three guidelines are:
1. Goal Evaluations
2. Skill Selections
3. Skill Performance Procedures
<table>
<thead>
<tr>
<th>Technique</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal Evaluations</strong></td>
<td></td>
</tr>
<tr>
<td>Determine overall necessity of training</td>
<td></td>
</tr>
<tr>
<td>Determine type of activities for training</td>
<td></td>
</tr>
<tr>
<td>Determine opo, what body systems/links/muscles and type of strength related to activities are to be trained</td>
<td></td>
</tr>
<tr>
<td><strong>Skill Selections</strong></td>
<td></td>
</tr>
<tr>
<td>What is the movement/motion?</td>
<td></td>
</tr>
<tr>
<td>What is the plane of movement/motion?</td>
<td></td>
</tr>
<tr>
<td>What is the axis of rotation?</td>
<td></td>
</tr>
<tr>
<td>What is the active/passive ROM at all joints involved?</td>
<td></td>
</tr>
<tr>
<td>What is the skill? (Motion applied to a specific activity)</td>
<td></td>
</tr>
<tr>
<td>• Discrete/non-discrete</td>
<td></td>
</tr>
<tr>
<td>• Closed/open</td>
<td></td>
</tr>
<tr>
<td>What is the variation of the fundamental skill?</td>
<td></td>
</tr>
<tr>
<td>What/where are the forces?</td>
<td></td>
</tr>
<tr>
<td>• Line of force (external versus internal)?</td>
<td></td>
</tr>
<tr>
<td>What systems are being stressed?</td>
<td></td>
</tr>
<tr>
<td>What are the primary/secondary movers?</td>
<td></td>
</tr>
<tr>
<td>What are the stabilizers?</td>
<td></td>
</tr>
<tr>
<td>What is static/dynamic throughout movement?</td>
<td></td>
</tr>
<tr>
<td><strong>Skill Performance Procedures</strong></td>
<td></td>
</tr>
<tr>
<td>Phases of the skill</td>
<td></td>
</tr>
<tr>
<td>• Preparation (set up and start position)</td>
<td></td>
</tr>
<tr>
<td>• Execution (performance of the motion/ROM at joints involved)</td>
<td></td>
</tr>
<tr>
<td>• Recovery (1 full movement or multiple repetition/ending position)</td>
<td></td>
</tr>
<tr>
<td>The “do I” principles</td>
<td></td>
</tr>
<tr>
<td>• Describe (the perfect/optimal technique)</td>
<td></td>
</tr>
<tr>
<td>• Observe (the technique performed/path of motion)</td>
<td></td>
</tr>
<tr>
<td>• Evaluate (technique/technical flaws/ROM at joints)</td>
<td></td>
</tr>
<tr>
<td>• Instruct (the proper individual style of technique)</td>
<td></td>
</tr>
</tbody>
</table>
The Basic Exercises

The following information pertains to standard techniques for basic Powerlifting movements. It is imperative that novice lifters understand the absolute BASICS of these three movements and possess a general understanding of how each of these lifts is performed to optimize individual styles of technique that are best suited to them for improving mechanical efficiency. To stay within the scope of this chapter, each of the following exercises will not be covered in detail; they will be covered in a way that will allow coaches, novices, or anyone seeking information on these movements to understand the basic techniques of each and optimize them accordingly.

These basic exercise movements will be covered and briefly described in this chapter:

- **Squats**
  - Bar position (high bar, low bar, and anything in-between)
  - Stance width (varies drastically based on body type, ROM, joint/bone formation, federation rules, etc.)
- **Bench Press**
  - Grip width variations
  - Flat feet or on toes
- **Deadlift**
  - Conventional style
  - Sumo style

We must re-emphasize the importance of the data collected from your assessment to individualize and optimize technique for all three lifts. The data comes from:

- **Posture**
  - Hip width
  - Q angle
  - Flat feet
  - Muscles length imbalances
  - Hip/shoulder height imbalances
- **ROM (range of motion at all major joints)**
- **Somatotype**
  - Fatness, muscularity, leanness
  - Segment lengths
- **Bone Formation**
  - Please note this is particular difficult to identify without subsequent high technology equipment (X-ray, MRI, etc.). There are a few tests to identify some bone formation discrepancies (anecdotal information) that may give you an idea of what is the source of any movement deficit.

Body Type Differences

Physiological functions are more closely related to biological age than to chronological age. At any given time, an early-maturing child has an advantage in measures of absolute strength when compared with a later-maturing child of the same sex who has less muscle mass. In general, the body type of early-maturing youngsters tends to be mesomorphic (muscular and broader shoulders; proportional segmental lengths) or endomorphic (rounder and broader hips; long torso and short upper and lower limbs), whereas those who mature late tend to be ectomorphic (slender and tall; short torso, long upper and lower limbs).

Physical differences in body proportions may affect the execution of resistance exercise. For example, short arms and a large chest cavity are an advantage in bench presses, whereas long legs and a short torso may be disadvantageous in squats. These factors have implications for strength and conditioning professionals who are attempting to standardize fitness tests or develop a resistance training program for a group of boys and girls who vary greatly in physical size. The reasons for individualized training programs should be explained to all participants, and special encouragement should be offered to those who mature later or who may be smaller and weaker than chronological-age peers with more biological maturity and therefore greater height and strength (Essentials, 2008, chapter 7, pages 144-145).

Every exercise has a basic technique; however, based on numerous human constraints (limitations), everyone must develop an optimal/individualized style of technique for maximizing effectiveness and to minimize the risk of injury.

The message is don’t copy a technique just because somebody else says their way is the only way to do it. Start with the basic style then augment to find the right style for every individual. This will also become clear when viewing the frame by frame pictures for each exercise to show/emphasize where the forces should be and how the movement should be performed (trunk angles, foot/hand placement and width, etc.). Once the technique is optimized for the individual, strength becomes the required variable to improve performance accordingly.
Squats

In 1991, the NSCA published a position paper (Stone and Chandler, 1991) stating that squats, when performed correctly and with appropriate supervision, are not only safe, but may be a significant deterrent to knee injuries. The squat can be an important component of strength and conditioning programs to improve an athlete's ability to forcefully extend the knees and hips, and can considerably enhance performance in many sports. Resistance training, including the squat exercise, strengthens connective tissue (muscles, bones, ligaments, and tendons). Proper form depends on the style of the squat and the targeted muscles. While squats result in high forces on the back, injury potential is low with appropriate technique and supervision. Injuries attributed to the squat may result not from the exercise itself, but from improper technique, pre-existing structural abnormalities, other physical activities, fatigue, or excessive training. There are different variations of the squat, all of which target a different purpose. Squats vary in depth, bar placement, and foot placement.

Note on stance width/foot angle

Stance width should be individualized for all squatting movements based on individual human constraints specifically body type/segment lengths. When adjusting foot stance width, it is important to ensure the foot is aligned with the direction the knee cap is pointing. Feet and knee misalignment may cause excess torque and limited joint range of motion at the knee joint.

Example

The above athlete has been performing strength and power routines since the age of 16. He grew taller than his neurological sense of muscle balance and coordination capacity. At the age of 18, his performance in strength, speed, and power increased greatly as compared to past years of training in his off-season periods. He began flexibility training to increase range of motion of muscles around the joints that were extremely tight. He performed static stretches, myofascial release techniques with a foam roller, eventually moving to the PVC roller.

As a youth hockey player, his functional balance of movement became dominant due to the position he played. He performed an overuse of one pattern, which became his dominant way of moving creating posture and strength imbalances. In the illustration, his right calf muscle is ¾” larger than his left calf. After a series of strength exercises, his strength performance became equal. This size difference can be explained as genetic and/or explained as his use of his dominant leg resulting in muscle hypertrophy. Two years was required to build this individual's physiological motor skills for performing a full squat with proper form, muscle control from multiple ranges of movement,
and excellent postural joint alignment. After 8 weeks of performing advanced strength training, his squat increased 80lbs over the previous year. Factors attributed to this success are psychological and physiological maturity, improved flexibility, improved biomechanical control, and improve joint and postural alignment.

The Q angle is a measurement of the angle between the quadriceps and the patella tendon. This provides useful information about the alignment of the knee joint, which, if outside of normal ranges, can be a precursor for overuse injuries. This is specifically important when coaching all squat and deadlift movements that activate the Lumbo Pelvic Hip Complex (LPHC). An excessive Q angle may also be described as “knocked knee” known as genu valgus.

**Functional Improvements**

The first evaluation is to understand this particular person is an unfit body to perform powerlifting sports-specific movements. The functionality of performing a seated position is extremely poor and never should add load of resistance to a person who produces these assessments results. A thorough biomechanical assessment is required by an appropriate health professional in order to progress with a treatment plan.

Correct biomechanics must be achieved through a rehabilitation program which focuses on restoring flexibility to tight muscles, strength to weakened muscles and relearn the functionality of corrective movement patterns. These muscle groups involve the LPHC, quadriceps, hamstrings, and calves. Muscles play an important role in controlling the stability and positioning of the joints. It is important to perform general fitness exercise programs that address the balance of strength of the joints, proper muscle movement to increase flexibility, and postural alignment. If this particular movement is possibly due to tight adductors and weak gluteus muscles, then static stretching and myofascial release is recommended to increase muscle lengthening to over tight muscles. Increasing flexibility of the adductor muscle groups will actually increase the stimulation of the gluteus muscle groups.

**Fig 12: Q Angle  Fig 13  Fig 14**

- 31 year old female
- 5’4” tall
- 127lbs body weight
- 28% body fat
- On disability from car accident
- Replaced ACL at age 26
- Has metal plate supporting right ankle

Fig 15 Reprinted with permission from USPA
**Thoughts on Depth**

In 2011 an article was published in the NSCA's Strength and Conditioning Journal addressing the continuing concerns over squatting depths that are commonly presented (Chiu and Burkhardt, 2011). These concerns have been an ongoing argument for five decades and are likely to have originated from Klein’s work (1961). Todd’s analysis of Klein’s work has suggested that below parallel squats, where the thigh and calf do not touch, were considered acceptable. This depth has been previously promoted by the National Strength and Conditioning Association in the Essentials of Strength Training and Conditioning text and in a position stand. Nevertheless, this variation of squat does not bode well with weightlifting movements. Full squatting depth (below parallel) with the thigh and calf touching at the bottom position of the squat, is necessary to ensure proper receiving positions for both weightlifting movements (snatch, clean and jerk) especially when attempting maximum efforts in both lifts. Research of squats performed to this depth demonstrates no negative effect on knee joint laxity and possibly an increase in knee joint ligamentous stability. Recent research has also cast doubts on the assertion that thigh-calf contact increases stress on the knee. Rather, contact of the thigh and calf generates a knee extensor torque, which would reduce the muscular demand of the quadriceps. The magnitude of the soft tissue contact-generated knee extensor torque appears to be large enough to substantially reduce the quadriceps tendon and patellar ligament forces, subsequently reducing patella femoral joint forces and pressures. Although future research is required in this area, these data support the low incidence of knee injuries observed in competitive weightlifters, with these lifters who typically perform some form of deep squats for hundreds of repetitions per week. This new data dictates all coaches, personal trainers, and fitness enthusiasts should be aware of using the previously mentioned assessments accordingly to verify this range of motion can be attained if weightlifting movements are to be performed. Additionally, these assessments are extremely useful to identify any range of motion deficits at various joints independent of weightlifting participation; therefore, these assessments are highly recommended and should be included along with all movement assessments. Please be aware that most powerlifting squats are just below parallel and may not be affected by this. Nevertheless, it is necessary to state this is due to variations in the type of squats used in training to target different areas that contribute to powerlifting squat performances. Many powerlifters use this type of squatting protocol; therefore, it is applicable to address this.
Low-bar Powerlifting Squats – Is there really an advantage?

There is much debate as to which type of bar position in the squat allows for higher numbers to be lifted. For most, the low bar allows for higher numbers with the difference being about 5 - 10% more weight lifted in the low bar position compared to the high bar or front squat (Nuckols, 2015). This controversy adds to the debate that the low bar position enhances posterior chain involvement and decreases quad involvement. This is dependent on the trunk angle throughout the movement (increased hip torque). A smaller trunk angle will increases trunk torque (hip joint torque) but decrease knee torque depending on the trunk angle (McLaughlin, et al., 1977). This also depends on the forward position of the knee at the bottom position of the squat.

McLaughlin’s work shows most high level lifters attempt to maintain a steeper trunk angle and not lean forward as much to increase the activity of the quads. Regardless of the bar position, every type of squat elicits maximum quad activity at the movement’s lowest position. This means that for any type of squat, regardless of the bar position, all will utilize both knee dominant and hip dominant positions depending on the position of the body during the movement. Another noteworthy point is choice of bar position is completely up to the lifter whether it be competition, training (high bar versus low bar), one’s goal(s), and/or comfort.

Here are three prominent key points all lifters should contemplate (Nuckols, 2015; McLaughlin, 1977):

1. If you assume similar mechanics, bar position makes little difference in the challenge presented to the quads and hip extensors.

2. The major mechanical differences arise because the quads are most challenged at the bottom of a squat, and most people are capable of squatting more weight in a low bar position (the knees and hips both shift back a bit)

3. Since the quads are maximally challenged at the bottom of both high bar and low bar squat and you’re capable of squatting more weight in a low bar position in spite of greater hip extensor demands, the logical separator: back strength (specifically thoracic spinal erectors).

So what is the bottom line?

The relative position of the bar between high-bar versus low-bar is only about 2 – 3 inches apart. This makes little difference in the mechanics during the individual’s display of technique if the lifter has not only excellent technique but substantial experience as well as superior erector strength particularly in the thoracic erectors.
The biggest difference is during the low-bar squat the trunk is bent slightly forward more causing the moment arm on the hip to increase slightly and decrease on the knee (depending on the lifter’s knee position). When the bar moves down the back the trunk must lean forward to maintain the bar’s position and not slide. The knees may not move as far forward compared to the high-bar or front squat; however, this is dependent on the lifter based on numerous variables to include segment lengths (trunk, thigh, shank), ROM at the hip, knee, and ankle as well as stance width. Many low bar lifters do move the knees forward to maintain a more erect trunk (McLaughlin, 1977). These two variables, trunk angle and knee position, are addressed by optimizing the stance width of the lifter to ensure the external line of force of the bar is positioned through the mid to rear foot (line of force is optimal through the ankle) as well as all segments optimally positioned and maintained throughout the movement for the individual. This is referred to as an optimal and individualized style of technique (Kreighbaum and Barthels, 1996).

As you can see from the above photographs every lifter may have a different bar position and stance width that loads the bottom position of the squat affecting the position of the knee. Each lifter, dependent on their ROM at the hip, knee, and ankle, as well as segment lengths (trunk, thigh, shank) and bone formation differences, will display their own individual style of technique which may place more or less stress on the hip or the knee (larger or smaller moment arm – horizontal line) depending on the style and phase of the squat. These moment arms are also directly affected by the angle of the trunk. Position of the bar, stance width, and segment lengths all have a direct influence on each segment’s position particularly the trunk angle.

A lifter can train using various types of squats (high/low bar, front, etc.); however, each lifter must identify various positions in selected assessments to determine how to optimize one’s individual style of technique for maximum force production to squat more weight. One evaluation protocol is to measure the length of selected segment lengths (e.g. trunk, upper/lower arm, thigh, shank). One must also measure the distance of the bar to the approximate hip joint for the various bar position specific to the type of squat (high bar versus low bar). Once these measurements are completed, one must evaluate/approximate each joint angle as well as each segment angle to develop a visual mechanical model for determining optimal segment angles throughout the full movement as well as ROM for each joint.

To help you visualize optimizing mechanics we used these measurements to make segment length adjustments on a two dimensional, adjustable anthropometric stick figure (shown below). This device’s segment links can be adjusted to an individual’s trunk, thigh, and shank segments lengths to identify joint and segment position angles while performing various types of squats (specifically high and low bar squats).

This device allows the viewer to identify moment arms, joint angles, and segment angles to compare and contrast the differences between high and low bar squats based on the individual’s proportions. While the bar position may be only a 2 – 3 inch variance, this small difference has a major effect on how the lifter will position themselves into a mechanically efficient position especially how the lifter will adjust the position of the knee and hip joints. Trunk and joint angles are also highly influenced by stance width (discussed later in this presentation).

Please note these observations are only from a lateral perspective (side view) with the feet assumed to be parallel to each other and approximately hip width apart. Shown is the initial start position and the bottom of the squat with the feet in a close stance position.

The data/information collected, when applied to this stick figure then analyzed accordingly, will give the lifter/coach...
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Guidance for a proper and individualized stance width and trunk/hip/knee positioning to optimize/individualize squatting technique based on the segment lengths, joint angles, segment angles, and knee/hip position placement data found between both high and low bar squats. This model will be used for both high bar and low bar squat measurements based on the above stance position and the distance from the bar to the hip joint. Please note the difference between high to low bar position. For our purposes, measurement data collected pertaining to the high versus low bar positions was performed on a small group of lifters with the average difference being approximately 2 inches.

We will use one lifter’s measurements for our example. The following data is:

- **High bar squat (bar on top of traps)**
  - Trunk length = 22 inches (bar to hip joint)
  - Thigh length = 14.5 inches
  - Shank length (lower leg plus foot) = 18.5 inches

- **Low bar squat (bar approximately two inches below high bar position across the spine of scapula)**
  - Trunk length = 20 inches (bar to hip joint)
  - Thigh length = 14.5 inches
  - Shank length (lower leg plus foot) = 18.5 inches

We adjusted our stick figure mechanical model to the approximate segment lengths for this lifter specific to the high bar squat. The first picture shown is the below parallel position of the high bar squat (remember this diagram is the reference point with the feet approximately hip width and from a lateral aspect only). Observe the position of the knee (just beyond the toe). This position is very common in many lifters (weightlifters and bodybuilders) who have excellent mobility.

The first item to be considered is the external line of force (yellow line) which is the loaded barbell. External force from gravity is always in a straight line downward. Next we must observe the moment arms on both the hip and the knee. This position is a below parallel high bar squat with the feet together (hip width). Notice the moment arm on the knee is larger than on the hip at this position (a moment arm is the perpendicular distance from the axis of rotation of the observed joint to the line of force). This picture is our reference to compare to all other positions.

Next we need to observe the angle of the trunk, thigh, and shank segments as well as the hip, and knee joints in this position (below parallel high bar squat). Segment angles are measured with reference to the floor.

One must consider variables for this position e.g. ROM at the hip, knee, and ankle as well as segment lengths of the limbs involved. As stated in research and training manuals, the high bar squat is an excellent movement for not only the quads and glutes but substantially loads the trunk muscles to maintain the erect position of the trunk. However, what if the lifter does not have the capacity...
to reach the above position? (Lack of mobility, muscle weakness to maintain or attain certain depths, etc.).

Using the same lifter, the following pictures show the differences in trunk, knee, and hip angles if the lifter cannot reach the above initial position (full ROM for the hip, knee, and ankle). Note the change in the positions of the knee as it is assumed of its inability to travel beyond the toe (this picture shows the knee just over the toe). Observe the substantial difference in the trunk, hip, and knee angles as compared to the previous series of pictures. This will change the stresses imposed on connective tissue and alter the mechanics of movement in the high bar squat. A simple shift rearward in knee position significantly alters the trunk, knee, and hip angles as well as the moment arms.

![Fig 34, Fig 35, Fig 36, Fig 37]

Now let’s observe the changes when the shank is vertical.

![Fig 38, Fig 39, Fig 40, Fig 41]

There are considerable differences between the three different knee positions and their effects on trunk, hip, and knee angles. These differences must be recognized to appreciate how force works both externally and internally. Please remember this example/reference shows the joint and force differences with specific segment lengths and with the feet approximately hip width.

Our next question is can we make any changes that will optimize these variables for a more effective high bar squat? The answer is yes. The answer is quite simple: experiment with finding the optimal foot stance width to ensure a more upright trunk regardless of the mobility in the hip, knee, and ankle.

In this next example, the lifter (whose measurements were used on our mechanical model) experimented with the same positions used in the reference. Please note this example is showing you the mechanical changes that will take place in a real time situation (competition or training).

The lifter sat on a box which positioned her in a just below parallel position, with feet approximately hip width, knees at ninety degrees and the bar in the high bar position on the back. The top of the hip is below the top of the knee making this a below parallel squat (indicated by the orange line).

With the feet approximately hip width apart, knees bent to a ninety degree angle (shank vertical), we will have the lifter attempt to stand up from this reference position. Observe the trunk angle as she leans forward to position the line of force of the bar over the base of support (feet). With her feet hip width, she must substantially lean forward to position the line of force appropriately. Notice this lifter must move her knees forward a bit to enable the trunk to maintain a more upright position; however, it was difficult for the lifter to stand up without using momentum to transfer her weight to the feet (base of support) and engage the legs to help her stand up.

In a real-time situation (competition or training), the lifter (using this close stance width) would have to excessively lean forward a certain number of degrees to position the body’s COM (center of mass with the bar) over the base of support (feet) properly depending on segment length and range of motion at each joint involved.
To offset this less than efficient position, we move the feet rearward to mimic the stick figure’s similar position for observing the changes in various angles (simulating the knee forward position by moving the feet backwards). With the feet moved rearward, one can see the trunk angle changes dramatically and enables the lifter to be more upright and changing the forces on the body. Notice the force production is shifted to quads with the trunk more upright involving more erector spinae to hold this trunk position (increased compression force versus shear force leaning forward).

Can we further optimize this lifter’s technique? Yes – we adjust the stance width to optimize force production and maximize the effectiveness of this optimized technique e.g. more upright trunk, stabilized stance width, and optimized starting position out of the bottom of the squat.

Performing a body weight squat is the starting point to show how the body, with adequate ROM, can assume a below parallel position in either the close or wider stance position. This also demonstrates how the body will naturally position the knee accordingly to balance correctly at the lowest position (positioning of the COM) as well as position the trunk at the appropriate angle depending on the length of the trunk, thigh, and shank.

Our stick figure showed various angles in the close stance position. Observe the change in trunk angle by simply moving the feet out wider. Every lifter must optimize their stance width to improve...
the trunk angle. This will assist in developing one’s individual style of technique for maximum lifts.

Substantial trunk angle difference with foot stance width position modified for optimizing style of technique. A wider stance produces a more upright trunk position and knees slightly more forward. This decreases stress on the lower back transferring it to the legs. A few degrees change in the trunk angle can substantially improve individual style of technique and performance while decreasing injury.

Let’s observe our model performing the same squat movement (bar position) with a wider stance to see the difference in angles by widening the feet in the various knee positions.

Observe that even with the feet widened she still must shift her knees forward to optimize her trunk angle. With the shins almost vertical it is still somewhat difficult to ascend even with her feet farther apart causing the lifter to lean too far forward. Many powerlifters squat with the shank vertical but substantially widen their stance width. However, as she comes off the box she has a more upright position than with the feet closer together.

As with the close stance position, our next step is to move the feet backwards to simulate the knees moving forward as the lifter ascends from the bottom position while maintaining a wider stance. Notice the substantial difference in the trunk angle.

Let’s look at another example:

This lifter has the segment lengths (approximate):
- Trunk length: 24 inches
  high bar, 22 inches low bar
- Thigh length: 17.5 inches
- Shank (with foot): 21 inches

The first series of pictures begins with the high bar squat:
- First picture – feet narrow
- Second picture – feet wider

Also notice the external line of force (straight line from the bar through the foot) is through the ball of the foot. The lifter is leaning forward with the knees extending past the balls of the feet. In the second picture the feet have been moved farther apart causing the trunk to be more upright and the external line of force through the ankle joint (approximately). The second series of pictures the lifter has moved the bar down the back approximately two inches (low bar position). The first photograph shows the feet close together but notice the knees are not as far forward and the trunk bent forward more. The second photo the feet have been moved apart which allows the trunk to be more upright and the knees have not moved from their original position. Also be aware that the external line of force has not changed either from the first photo using the low bar position.
This next example shows a lifter using a low bar position using a wider stance based on the segment lengths of this individual. In this example the lifter’s knees do not move as far forward but the relative trunk angle is the same as our other lifter shown above.

One must also note that segment lengths will vary drastically between lifters. The example below shows our stick figure indicating a lifter with a short trunk, long femur, and short shank. With the low bar position and feet close together, one can see the differences of moment arm length based on the position of the knee as well as the relative trunk angle. This demonstrates the importance of optimizing the stance width for every individual to ensure optimal technique and maximum force production through every position throughout the entire squat movement.

In the above diagrams, the figure has a short trunk, long femur (thigh), and short shank (lower leg). The reference stance width is approximately hip width. If the lifter has excellent ROM at the hip, knee, and ankle then the lifter will be observed in the below parallel squat position noted in Figure 63. If the lifter cannot move the knees forward as far as in Figure 63, then the trunk will be forward more with the stress shifted to the lower back (Figure 64). If the ROM at the knees and ankles are even more limited, or the lifter is told not to move them forward to keep the shank (lower leg vertical), then the trunk bends forward even more to further stress the lower back (Figure 65).

With this situation, the lifter must move the feet farther apart (move the stance width wider) to move the trunk into a more upright position which transfers the load/force production to the legs for improved performance. This is the standard protocol for every lifter to optimize stance width to maximize performance and minimize injury.

If we compare and contrast each position from the above examples we see the tremendous differences segment length, joint ROM, and stance width have on optimizing one’s style of technique on any type of squat. Data from bone formation tests will also alter technique in conjunction with these variables. Please also remember the numbers one collects are all specific to the individual lifter’s unique variables previously listed. Every lifter must identify what characteristics alter one’s mechanics then experiment to optimize the individual’s style of technique for lifting heavier weights with the best mechanics. Stance width is the final deciding factor for optimizing style of technique.

In conclusion, there is very little difference between high-bar versus low-bar squats. Low-bar squats allow for approximately 5 – 10% increase of load lifted; however, many powerlifters may use this type of squat (low-bar) but the position of the bar will vary drastically between lifters. Segment length, range of motion, and bone formation variations all alter squat mechanics. The primary variable for optimizing style of technique in all squats is the stance width even if the lifter has good mobility. Stance width depends on experimentation to determine how wide the lifter must position their feet for optimization of technique and proper force placement.
Additional Tests

There are three additional tests coaches and lifters can use to determine one’s ability to squat below parallel (mobility at hip, knee, and ankle), optimal stance width, and the ability to stand erect for both the squat and deadlift. These tests are:

1. Supported Squat
2. Bridging
3. 4 by 4

Supported Squat

This is a straightforward test to determine one’s ideal squat depth as well as determining what your optimal stance width should actually be when squatting. Begin with finding a solid object to hold on to such as a squat rack or bench (something that is fixed and will not move).

Next – hold onto the fixed support, assume a stance width about hip width, and squat down as low as you can with a the back as straight as possible with a neutral pelvis. The goal here is to identify how deep you can squat without tucking your pelvis under and maintain a straight back position.

Once in your lowest squat position, move your feet in to see if your depth changes then move the feet out wider than your original position. This will help you identify the best stance width to achieve the maximum squat depth independent of a pelvic tuck.

Upon finding your optimal stance width, let go of the support and attempt to balance without holding on.

Next – put your hands behind your head and balance on the whole foot (feet in this instance). The hands behind the head will assist the lifter in trying to lift the chest as one does during a squat movement with the bar on the upper back. This will be the starting point to identify your ability to squat below parallel without support.

Again the main point in this assessment is to see if a lifter is capable of squatting below parallel while achieving an optimal stance width and how to optimize the angle of the feet depending on how wide the stance width is. As one can see from the above pictures the lifter can achieve a below parallel position but has difficulty with achieving a very straight back. Please note that there is no right or wrong here but simply a way to ascertain the range of motion for the squat as well as the lifter’s optimal stance width. This test also can identify lack of hip flexion which may be a problem in the conventional deadlift starting position. This test gives the lifter information for adjusting stance width accordingly (modified wide to wide stance, modified close to medium stance, etc.) for both the squat and deadlift. Please review the assessment chapter pertaining to bone formation and somatotype differences that directly alter style of technique especially stance width (base of support).
This is a very simple test to identify one’s ability to bring the hip into a neutral or hyper extended position (just past neutral. This test is basically the same as a bridging exercise to focus on strengthening the posterior chain muscles. The lifter begins by lying on their back, knees bent to 90 degrees, feet flat on flat and together. Once this position is assumed, raise the hips up as high as one can (arched the back).

The goal here is to assume a neutral hip position (straight line from the knees to the shoulders). If the lifter has less than the above position, it may indicate tight hip flexors and weak lower abdominals. Notice the lifter has her hands behind her head. If the lifter can assume neutral or better in this position, the ability to lock out a squat or deadlift is inferred. One can also put the hands to the side of the body since this is more specific to holding a deadlift bar. It is recommended both positions are performed. If the lifter can achieve a more than neutral position with the hands behind the head, it is a good indication of achieving a substantial arch during the bench press (notice the lifter is on top of the scapula which is required to lift the chest in the bench press for optimal ROM).
4 by 4 (Goalie Stretch)

This test is to identify the lateral capability of the hip joint. It is an excellent assessment to identify ROM of the lateral aspect of the hip joint especially for those powerlifters wanting to take a wider than normal stance width.

The lifter begins by assuming a position on all fours on the floor (fig 73). The hands and elbows are on the floor as are the knees and feet to start (two hands, two elbows, two knees, two feet – hence the designation “4 by 4”). The starting position is with the knees about hip width. The feet can be straight or on the toes.

From this position the lifter will shift their hips backwards toward the feet (fig 74). The goal here is to identify if the lifter can move the top of the hips below the top of the knee. Once the back begins to round the test stops for this particular position of the knees (hip width).

Next – the lifter will widen the knee position (laterally) to see if the hips will remain in a neutral position and flat back while moving the top of the hips below the top of the knee (fig 75).

The lifter will continue to move the knees laterally until it becomes uncomfortable (fig 76). This will indicate the optimal stance width position that should be used. This test/assessment helps to confirm the genetic hip socket position the leg can be put into. While many coaches state lifters should use a very wide stance this test can confirm if one can actually assume a wide stance and identify how wide a lifter’s squat stance will be.
Conventional Powerlifting Squat  
(low bar squat)

Preparation Phase (Starting Set-up and walk out)

- Grasp the bar with a closed, pronated grip (grip width will vary).
- Step under the bar and place the bar in a balanced position just below the top of the trapezius.
- **Low bar position** — across the posterior deltoids at the middle trapezius and the spine of the scapula (using a handgrip wider than shoulder-width). Lift the elbows up to a comfortable position to create a “shelf” for the bar using the upper back and shoulder muscles.
- Please note there are many cues for bar placement.
  - “Bend the bar”
  - “Pull down on the bar”
- There are also various hand placement ideologies specific to:
  - Shoulder joint ROM
  - Arm length
  - Personal preference
- The primary concern is to ensure the bar stays in place once the bar is positioned on the back. For taller lifters the use of a longer bar will be necessary (as shown in the below picture where the lifter’s hands are touching the weight. Use of the longer bar inhibits this).
- Push bar upward from squat rack stands and take one step backwards
- Position the feet accordingly
  - Stance width will be wider than shoulder wider
  - Width will vary depending on torso/leg length ratio and individual preference.
  - Once individual stance width has been established, the lifter must ensure the feet are in line with where the knee caps are pointing
- Head looking straight ahead

Starting Position: Front/Rear Views
Execution Phase One (Descent Phase)

- Maintain a position with the back flat, elbows positioned suitably to stabilize bar in this position, and the chest up and out.
- Begin the movement by moving the hips rearward first then allowing the knees to slowly flex while keeping the torso-to-floor angle relatively constant.
- Head position is neutral
  - Avoid looking upward (NOTE: This varies considerably between coaches and federations).
  - Some lifters maintain the neutral position throughout the movement
    - As the lifter approaches bottom of this lift, maintenance of this neutral head position gives the appearance the lifter is looking down. This is highly individual for every lifter.
- The lower leg may stay in a vertical as possible
  - Varies with the individual
  - Research indicates that the load is maximal for the quads in the bottom position regardless of the lower leg position. Again this is highly individual with much anecdotal data showing most lifters do push their knees forward at the bottom position of the squat. Type of equipment (e.g. squat suit) will substantially alter positions of the segments.
- Keep the heels on the floor and the knees aligned over the feet.
- Knees over the ankles from the front view position
- Continue flexing the hips and knees until the thighs are parallel or slightly below parallel to the floor
- External line of force through the ankle
- Knee moment arm may be smaller than hip moment arm
  - This varies considerably between lifters.
- Knees over the ankles from the front view position (knees do not buckle inward)
- Discontinue the descent if
  - The trunk begins to round or flex forward
  - The heels rise off the floor
  - The pelvis tucks under (posterior tilt or commonly called “butt wink”)
Execution Phase Two (Ascent Phase)

- The primary movement here is to push the hips backwards as the lifter rises from the bottom position.
  - Depending on the lifter’s style of technique, the moment arms of the hips and knees will change dramatically as the lifter rises rapidly from the bottom position.
  - All variations of the squat movement involve the quadriceps, hamstrings, glutes (all sections), abductors, and adductors. Degree of usage depends on style of technique as well as the position of the body throughout the movement.

- Maintain a position with flat back, elbows positioned to stabilize bar on upper back (bar should not shift or roll during the lift), and the chest up and out.
  - Extend the hips and knees at the same rate (to keep the torso-to-floor angle constant out of the bottom position of the squat. This will change once the sticking point is reached). Do not flex the torso forward or round the back.

- Keep the feet flat (weight on the whole foot) and the knees aligned over the feet
  - Knee position over feet will vary substantially between lifters
    - Some lifter’s knees will move forward over the toes while many will have the knee directly over the ankle. This is based on the technique used by the individual.
• The lifter should raise the head and look up (chin “up”) and “push the hips forward” at the sticking point of this movement.

- The “sticking point” is considered the phase of the upward movement when the posterior chain has completed its task and the force production is transferred to another muscle group (optimization of force) to complete the lift.

• Continue extending the hips and knees to reach the starting position.

Fig 92 Fig 93

Mid Position/Sticking Point

Fig 94 Fig 95

Mid-point/Sticking Point and Scoop-through

Fig 96 Fig 97

Finish Position Squat

(“Movement Evaluation Guidelines” on page 27)
DESCRIPTION
Individualized stance width (toes and knee caps aligned)
Preparation
Position of bar on upper back
Grip width spacing
Lifting of bar from rack and one step back
Set stance width according
Chest up – eyes looking
Wait for referee’s signal
_Inhale deeply (fill lungs and belly with air) and hold_

EXECUTION
DESCENT
• Maintain a position with the back flat, elbows high, and the chest up and out.
• Lead the movement by moving the hips rearward first then allowing the knees to slowly flex while keeping the torso-to-floor angle relatively constant.
• The lower leg should maintain as vertical as possible
• Varies with individuals
• Keep the heels on the floor and the knees aligned over the feet.
• Knees over the ankles from the front view position
• Continue flexing the hips and knees until the thighs are parallel or slightly below parallel to the floor
• External line of force through the ankle
• Knee moment arm much smaller than hip moment arm
• Knees over the ankles from the front view position (knees do not buckle inward)
• Speed of movement will vary with lifter

ASCENT
• transition from down to upward movement should be explosive in nature
• hips/shoulders rise at same time

RECOVERY
If one rep re-rack bar
If multiple reps maintain prep position

OBSERVATION
• maintain optimal trunk angle
• knees in line with feet
• hips and shoulders rise at the same time
• controlled descent and explosive movement from bottom position of squat
• no rounding of back throughout movement

EVALUATION
_Optimal position/flaws throughout entire motion_
• timing of links during ascent, transition, and ascent

INSTRUCTION
_Individualization of optimal style of technique_
Lower Body Pulling Movements

Conventional Deadlift

Starting Position

- Stand with the feet flat and placed between hip- and shoulder-width apart with the toes pointed straight or slightly outward (lifter preference).

- Position the bar approximately 1 inch (3 cm) in front of the shins and over the balls of the feet. Standing slightly away from bar allows the lifter to position the body properly. Standing too close to the bar pushes the shoulders forward of the bar in an disadvantageous position and may cause the hips to rise prematurely upon bar separation from the floor.

- Inhale deeply, hold breath, then squat down with the hips lower than the shoulders, and grasp the bar with a pronated or a closed, alternated grip.

- Place the hands on the bar slightly wider than shoulder-width apart, outside of the knees, with the elbows fully extended.

- Position the body with the back flat.

- Chest held up and out.

- Head in line with the vertebral column.
  - Line of sight in line with the head position or eyes looking forward.

- Some lifters pull head back/chin up. NOTE: this head position tends to push the hips forward.

- Heels in contact with the floor.

- Shoulders over or slightly in front of the bar (lifter preference or dictated by how close lifter is to bar).

As mentioned at the beginning of the chapter of the body type differences, notice the length of the femur as compared to the length of the upper torso. Is this a leverage advantage or disadvantage? Notice the degree of forward lean of hip flexion. Recognize the style of technique or performance.
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Upward Movement Phase

- With arms pulled tight, holding breath, pulling the torso rigid (tight lordosis), shift weight rearward to distribute weight on entire foot. Once the shift is complete, lift the bar off the floor by extending the hips and knees.
  - Movement cue is “push the floor away from the bar.”
- Keep the torso-to-floor angle constant; do not let the hips rise before the shoulders.
- Attempt to maintain a rigid flat-back position.
  - Upper back (thoracic area) may round slightly. This is acceptable but must be monitored to ensure the upper back does not excessively flex forward.

- Keep elbows fully extended and the shoulders over or slightly ahead of the bar
- As the bar is raised, keep it as close to the shins as possible
- As the bar rises just above the knees, push hips forward to move knees forward and under the bar. The trunk will move toward a more erect position to facilitate extension of the knees to finish this movement.
  - This is called the “scoop”
  - Transfers primary force production from posterior chain to anterior chain (knees forward to create a “knee extension movement pattern”)
- Continue to extend the knees and hips until the body reaches a fully erect torso position.
Sumo Deadlift

Starting Position

• Stand with the feet flat and placed wider than shoulder width with the toes pointed outward to align knees and feet.

  - Width of stance varies according to lifter preference and/or body type.

• Place the hands on the bar slightly wider than shoulder-width apart, inside of the knees, with the elbows fully extended.

• Place the feet flat on the floor and position the bar approximately 1 inch (3 cm) in front of the shins and over the balls of the feet.

  - Positioning the bar away from the shins allows the lifter to squat down and position themselves correctly. If the lifter is too close to the bar, it will cause the lifter to lean too far forward creating a forward leaning starting position (COG too far forward). This forward position will shift the COG forward at the initial pull from the floor and decrease leg usage.

• Position the body with the back flat (rigid lordosis).

• Chest held up and out.

• Head in line with the vertebral column or slightly hyperextended

  - Line of sight in line with the head position

  - Having the head tilted too far back shifts the hips forward and will cause the hips to rise first upon the initial pull from the floor. This creates an inefficient position (no leg drive)

• Heels in contact with the floor,

• Shoulders over or slightly in front of the bar

• Lifter should take a deep breath first (super-stiffening method), tighten the abdominals while holding one’s breath, straighten arms tight, then squat down with the hips lower than the shoulders, and grasp the bar with a pronated or a closed, alternated grip.

• While holding breath (super-stiffening), push abdomen tight against belt, and shift body’s COG rearward. The premise here is to distribute one’s bodyweight evenly on the whole foot (equal weight distribution). The lifter should feel pressure on the whole foot before attempting to lift bar from floor

Upward Movement Phase

• While maintaining the super-stiffening position, COG rearward, and weight distributed evenly on entire foot, lift the bar off the floor by extending the hips and knees.

  - Movement should be similar to a wide stance squat utilizing more legs than back

  - A common coaching “cue” is “push the floor away from the bar.”

• As the bar separates from the floor, keep the torso-to-floor angle constant; do not let the hips rise before the shoulders. Hips and shoulders rise at the same time.

  - Torso angle should be more upright throughout movement as compared to conventional deadlift.
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- Keep elbows fully extended and the shoulders over or slightly ahead of the bar
  - This is lifter dependent
- Maintain even weight distribution on the feet (pressure should be evenly distributed)
  - If the shoulders are too far in front of the bar, this may indicate:
    - COG too far forward (weight distribution is uneven on the feet)
- As the bar is raised, keep bar as close to the shins as possible
- Maintain knee/ankle alignment throughout lift (knees over ankles)
- As the bar rises just above the knees, push hips forward to move thighs against and knees under the bar
  - This movement is the same as the conventional deadlift scoop movement
  - This movement transfers the load/force to the quadriceps and assists the lifter to engage the “knee extension” movement

(“Movement Evaluation Guidelines” on page 27)

<table>
<thead>
<tr>
<th>Goal Evaluations</th>
<th>Increase lower body pulling strength</th>
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<tr>
<td></td>
<td>Between sagittal and transverse planes</td>
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<td></td>
<td>(Conventional – sagittal plane; sumo – between sagittal and transverse)</td>
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<td></td>
<td>(Dynamic – hip, knee, ankle)</td>
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<tr>
<td></td>
<td>(Static – trunk musculature)</td>
</tr>
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</table>

|                  | Conventional deadlift |
|                  | Sumo deadlift |

|                  | Hip, knee, and ankle link system |
|                  | (Emphasis on posterior chain) |
|                  | • Glutes, hamstrings, quads (dynamic) |
|                  | • All erector spinae (static) |
|                  | • All core musculature (static) |
|                  | Types of strength: maximum/absolute, mrfd (strength-speed, starting/explosive) |
Skill Selections

- Sagittal plane (conventional)
- Sagittal extension/transverse abduction
  (Wide stance places feet between each)
- Hip, knee, ankle extension
  (Rom varies with squat variation)
- Skill – pull like movement (actual is pushing with legs)
  - Closed skill
  - Discrete skill
  - Wide stance variation

**External forces – gravity (straight down)**

**Internal forces – glutes, hamstrings, quads (concurrent shift)**
- Line of force: gravity is straight down; muscle line of force depends on the angle of pull of the muscle

**Systems being stressed – lower body link**
- Major dynamic stress on glutes, hamstrings (dynamic) and quads
- Major static stress on trunk musculature
  Note: dynamic/static stress on musculature will be determined by body type (angle of trunk at lift-off position)
- Lower link system (dynamic); trunk system (static)

**Primary movers**
- Dynamic: glutes, hamstrings, quads
- Static: erector spinae, scapula

**Stabilizers (lower):** adductors, abductors, external rotators
**Stabilizers (upper):** traps/rhomboids (shoulder girdle)

Skill Performance Procedures

**Description**

**Starting position**
- Stand with the feet flat and placed between hip- and shoulder-width apart with the toes pointed slightly outward.
- Squat down with the hips lower than the shoulders, and grasp the bar with a pronated or a closed, alternated grip.
- Place the hands on the bar slightly wider than shoulder-width apart, outside of the knees, with the elbows fully extended.
- Place the feet flat on the floor and position the bar approximately 1 inch (3 cm) in front of the shins and over the balls of the feet.
- Position the body with the back flat
  - Chest held up and out,
  - Head in line with the vertebral column or slightly hyperextended
    - Line of sight in line with the head position (8a)
  - Heels in contact with the floor,
  - Shoulders over or slightly in front of the bar

**Ascent**
- Lift the bar off the floor by extending the hips and knees.
  - Lifter should “sit back” to feel weight on the entire foot
  - Shoulders should be over or just slightly in front of bar
- Keep the torso-to-floor angle constant; do not let the hips rise before the shoulders.
- Maintain a flat-back position.
- Keep elbows fully extended and the shoulders over or slightly ahead of the bar
  - As the bar is raised, keep it as close to the shins as possible
  - As the bar rises just above the knees, push hips forward to move thighs against and knees under the bar
- Continue to extend the hips and knees until the body reaches a fully erect torso position

**Observation**
- Watch to see if hips rise before shoulders (both should rise together)
- Back flat (no rounding of shoulder/upper back
- Bar kept close to body (bar can be “dragged” up legs
- Observe if legs straighten too prematurely

**Evaluation**
- Optimal position/flaws throughout entire motion
  - Timing of links during ascent, transition, and ascent

**Instruction**
- Adjustment of links to optimize technique based on bodytype and structural/link system deficits
Upper Body Pushing Movements

Barbell Flat Bench Press

This movement, for many years, was the “staple” test of strength. Until recently, when one inquired how strong a person was, the question was “how much can you bench?” This movement is still a foundational test for upper body strength in many testing protocols. The bench press is the second test of strength at a powerlifting competition.

While this movement seems relatively simple, it is more complicated than once thought. Many coaches pay little attention to identifying how mechanics (specifically kinetics/kinematics) truly play a part in performing this movement effectively. Mechanics are also very much influenced by body type/limb lengths, muscle fiber arrangement/shape of muscle, and movement through the primary plane of motion to impact this movement and are vitally important for optimizing technique to maximum performance and minimize injury.

Many powerlifting coaches, as well as numerous high level powerlifters, have proclaimed that their mechanical explanations are considered optimal for all lifters. As previously stated there is no one all-encompassing technique that fits and benefits every person. There are fundamental technique guidelines for performing any basic movement; however, each person will need to individualize their style of technique based on a number of variables to include body type (segment lengths), range of motion (ROM) at a movement’s associated joints, and joint/bone formation variations that may alter their unique mechanics specific to this movement.

The Basics

Before embarking on a detailed mechanical analysis of this movement, we must review the basic rules describing what the judges are looking for in a properly performed bench press at a powerlifting competition. Please note there are many powerlifting federations with each having their own performance rules and guidelines. The NCCPT adheres to the USPA rules. Therefore, we will use the USPA rules to begin our review.

The basic guidelines for the bench press are:

- The lifter must lie on his/her back with shoulders and buttocks in contact with the flat bench surface. This position must be maintained throughout the lift. The head may remain flat or rise during the lift. The lifter has the option of benching while either flat footed, or on the toes, as long as the foot remains in contact with the lifting platform. The heel of the foot may move up and down during the lift as long as the toe remains on the ground.

- The grip may not exceed 81 cm (32 inches) meaning the index finger must be touching the lines on the bench bar.

- The lift must start with the arms (elbows) in a locked position over the chest. Once the bar is motionless the referee will give the signal “START” and the lifter will lower the bar to the chest.
The position the bar is lowered to on the chest is to the end of the sternum to the top of the abdomen. A lifter can lower the weight to any position on the chest but the rules state this is the position the judges are looking for. Once the lift has begun, the lifter must lower the bar and hold it motionless on the chest or abdominal area with a definite and visible pause. At no time may the bar come in contact with the lifter's belt.

Once the bar is paused and motionless on the chest or abdominal area, the audible command “PRESS” will be given. The bar must be pressed upwards with elbows fully locked. Any pronounced or exaggerated uneven lockout of the bar after completion is not allowed.

- Note: If a lifter has any physical abnormality, handicap or incapacity of extending their arm or arms to arm’s length with elbows fully locked, they must inform and show physical, visual proof to the Head Referee prior to the start of their lift.

Basic reasons for a lift to be considered a “no lift”:

- Any change in the elected lifting position during the lift, other than the head (i.e. any raising movement of the shoulders or buttocks from their original points of contact with the bench, or lateral movement of the hands on the bar after the “START” command has been given.) Feet must remain in contact with the floor, however, incidental movement as much as half the length and half the width of the lifter’s foot is permitted.
- Heaving, bouncing, or sinking the bar after it has been motionless on the chest or abdominal area, and the “PRESS” command has been given.
- Any pronounced uneven lockout of the arms during the completion of the lift.
- Any downward movement of the bar in the course of being pressed out.
- Failure to press the bar to full extension of the arms at the completion of the lift.

Where do you start?

We will begin our investigation/analysis with studying the shoulder girdle system (scapula, clavicle, and arm). This will facilitate our understanding of the mechanics involved to observe what type of motion and action is involved with this system in the bench press. We see the bench press “action” as a pushing action. This pushing action involves moving the barbell primarily through the transverse plane of motion. The arms will move at the shoulder and elbow joints causing a slight curvilinear bar path as the bar is pushed upward from the chest. We must also analyze what part of this system is involved dynamically and statically in this motion. To create this “push like action” we must analyze the primary muscles involved dynamically in the bench press (muscles “pull” on bones to create “pushing” or “pulling” actions). In conclusion, we must utilize all collected information pertaining to the shoulder girdle to analyze how the bench press movement is performed (as stated above) for seeing/observing/analyzing the primary plane(s) of motion, joints and systems involved, phases of the movement then determine what muscles are utilized in all phases of this movement (primary movers, secondary movers, passive and active stabilizers) as well as dynamic versus static actions.

The Shoulder Girdle

According to Wikipedia the shoulder girdle or pectoral girdle is the set of bones which connect the upper limbs to each side of the axial skeleton. In humans the shoulder girdle consists of the scapula, clavicle, and arm. The pectoral girdles are to the upper limbs as the pelvic girdle is to the lower limbs; the girdles are the parts of the appendicular skeleton that anchor the appendages (arms and legs) to the axial skeleton.

In humans, the only true anatomical joints between the shoulder girdle and the axial skeleton are the sternoclavicular joints on each side of the sternum (manubrium section). No anatomical joint exists between each scapula and the rib cage; instead the muscular connection or physiological joint between the two permits great mobility of the shoulder girdle compared to the compact pelvic girdle; because the upper limb is not usually involved in weight bearing, its stability has been sacrificed in exchange for greater mobility.

The previous description states “because the upper limb is not usually involved in weight bearing, its stability has been sacrificed in exchange for greater mobility.” This statement seems somewhat contradictory since this section of our chapter deals with the bench press; however, this statement may be specific to those who do little resistance training though most people perform weight bearing movements involving the upper limbs in activities of daily living. While evolution may have influenced the design
and formation of the shoulder joint and girdle for activities unrelated to weight bearing movement, we must briefly examine its normal function and how it is very much involved during weight bearing activities (specifically, in this case, the bench press movement).

**Upper Body Mobility**

As stated the shoulder girdle consists of the scapula (shoulder blade), the clavicle (the collar bone), and the arm. It is a complex structure having efficiency in numerous movements (multi-planar) but has considerable weakness (shallowness of the glenoid fossa) causing it to be susceptible to injury due to the many situations that increase its probability to substantial stresses. Joints of the shoulder girdle include (Kendall et al., 2005):

- **Sternocostal:** Connects the sternum (breast bone) with sternal ends of 10 ribs (7 directly and 3 indirectly)
- **Sternoclavicular:** Connects the manubrium of the sternum with the medial end of the clavicle.
- **Acromioclavicular:** Connects the acromial process of the scapula with the lateral end of the clavicle.
- **Glenohumeral:** Connects the head of the humerus and the socket of the glenoid fossa (ball and socket joint).
- **Costovertebral:** Includes the connections of the head of each rib with two adjacent vertebral bodies and the connection of the tubercle of each rib with the transverse process of the vertebra.

The scapula and clavicle always move as unit. The clavicle’s articulation with sternum is only bony link to axial skeleton (some texts also include the humerus). The shoulder girdle is considered to have a scapulohoracic rhythm, meaning the scapula moves on the rib cage. Joint motion also occurs at the sternoclavicular joint and to a lesser amount at the acromioclavicular joint. Therefore, shoulder girdle movements = scapula movements i.e., wherever the scapula goes, the clavicle follows and vice-versa (Floyd, 2012). Movement at the glenohumeral joint involves scapulohumeral rhythm meaning there is a ratio of scapular to humerus movement depending on the position of the humerus at the glenohumeral joint. Most textbooks state the maximum ratio is 2:1. The humerus will move 2 degrees with the scapula moving 1 degree. This will be maintained until a certain position of each then there will be a 1:1 ratio to ensure the glenoid fossa will be positioned accordingly to safeguard the movement of the humeral head in the socket.

**Sternoclavicular Joint**

Note: scapula and shoulder joint movements start here!!!

- (Multi-axial) arthrodial classification (multi-dimensional movement)
- Movements – in relation to manubrium, clavicle moves
  - anteriorly 15 degrees with protraction
  - posteriorly 15 degrees with retraction
  - superiorly 45 degrees with elevation
  - inferiorly 5 degrees with depression
  - some slight rotary gliding movements
For the purpose of this section on bench press mechanics, we will focus on the basic movements of the shoulder girdle primarily involving the glenohumeral joint. The scapula and clavicle are in a static or “fixed” position during the bench with only the arm in motion during the bench. Therefore we will focus on the arm moving at the glenohumeral joint.

**The glenohumeral joint**

Known as the shoulder joint, this is a multi-axial ball-and-socket joint (enarthrodial) meaning it moves in all planes of motion much like the hip joint. While motion of the shoulder joint is similar to the hip joint, its depth is extremely shallow and relatively small in comparison. This shallowness increases its susceptibility to dislocation and injury. Nevertheless, the shoulder joint is enhanced slightly by the glenoid labrum, a small cartilaginous ring or lip of cartilage surrounding the glenoid fossa just inside its periphery. It is further stabilized by numerous anterior and posterior ligaments, which become taut during the multiple motions associated with this joint (Kendall et al., 2005; Floyd, 2012).

Since the shoulder joint (glenohumeral joint) is multi-axial the arm moves through each cardinal plane of motion as well as through multiple planes (cross body movements such as throwing movements).

When considering glenohumeral joint kinematics, the motion of the humerus is measured with respect to the glenoid fossa of the scapula. The glenohumeral joint has 3 rotational **DoF (degrees of freedom)**: flexion/extension, abduction/adduction (frontal and transverse planes), and internal/external rotation (sagittal and transverse planes). Each movement the humerus performs moves parallel with the associated plane and around the related axis of rotation. It also has 3 additional DoF i.e. movement along an axis of rotation giving it 6 total degrees of freedom.

**Two examples of DoF within the human body:**

The primary movements of the shoulder joint are (Floyd, 2012; Kendall, 2012; Baechle and Earle, 2008):

- **Flexion:** Movement of the humerus straight anterior only from any point in the sagittal plane.
- **Extension:** Movement of the humerus straight posteriorly from any point in the sagittal plane (also referred to as hyperextension when extension extends behind the torso).
- **Abduction:** Raising the arm upward laterally and away from the body in the frontal plane.
- **Adduction:** Lowering the arm from an abduction position in the frontal plane.
- **External Rotation:** Movement of the humerus laterally in the transverse plane around its long axis away from the midline.
• **Internal Rotation:** Movement of the humerus in the transverse plane medially around its long axis toward the midline.

• **Horizontal flexion/Transverse abduction:** Movement of the humerus in the transverse plane away from the midline of the body (chest).

• **Horizontal extension/Transverse adduction:** Movement of the humerus in the transverse plane toward the midline of the body (chest).

NOTE: The angles shown in the above pictures are related to the actual movements shown and do not represent the full range of motion at the shoulder joint in all planes of motion.

Note: Horizontal Abduction and Adduction are also stated as Transverse abduction/adduction or Horizontal Flexion/Extension depending on the textbook used for referencing.
If one abducts the arm to the position it is parallel with the ground (position 1) then move the hands close together (position 2) this is considered moving through the transverse plane around the longitudinal axis (horizontal flexion or transverse adduction). This is the primary plane of motion for the bench press.

The arms straight out to the sides (upper arms at approximately 90 degrees to the long axis of the body) will activate the upper part of the pectoralis major (clavicular). To activate more sternal fibers the arms should be lowered to approximately 70 degrees. From this position bend the elbows.

Next the lifter holds a PVC pipe to the end of the sternum with the arms bent. The upper arm angle will vary considerably depending on the position the lifter holds the bar on the chest. The rules state the bar can be no lower than the end of the sternum/top of the abdomen. The starting point is the bar at the end of the sternum as well as the 70 degree reference for the upper arm. The arrows below are vectors showing the resultant force of the area of the pectoralis that should be targeted (Blue arrow).
Here is another example of the same bar reference; however, notice the angle of the upper arm is approximately at the same angle. Please note that the reference angle is from a standing position for identifying a starting point for the bar position on the chest. The angle of the upper arm will vary considerably between lifters depending on grip width, position the bar comes to the chest, and angle of the chest depending on how much of an arch the lifter will assume. This angle will also change substantially when the lifter depresses and retracts the shoulder blade for stabilization and optimization of the glenoid fossae for the humeral head to roll, slide, and glide correspondingly.

![Fig 165](image)

From a lateral view the elbows should form a straight line from the hands to the elbows. This will be the position when the lifter is on the actual bench. This position shows the internal forces (muscles that cause the movement of the arms in this plane of motion) are directly opposing the external line of force i.e. gravity. There is also a difference in body position depending on if the lifter is standing erect or leaning back. The upright position simulates a standard position on the flat bench (normal lordotic curve). When one leans backwards slightly it simulates assuming an exaggerated arch when on the bench. The large arch allows the lifter to alter force production from the lower sternal fibers similar to a decline position and increased force production.

![Fig 166](image)  ![Fig 167](image)

This leaning back position again simulates an exaggerated arch as well as the shoulder blades being depressed and retracted to stabilize the shoulder girdle and raise the chest up. Setting/locking the shoulder blades tight and hard enables the lifter’s chest to be pushed upward to decrease the distance the lifter must push the bar from the chest to completion of the lift (based on the rules of competition). Depression of the shoulder blades also activates the latissimus dorsi muscles to passively stabilize the arm and facilitate alignment of the hands and elbows directly in opposition of the external force (linear force system). This position is to be maintained throughout the lift (descent and ascent). A position where the chest is more toward a decline bench press will activate more of the sternal pectoralis major to produce more force. This decline like position will enhance performance based on one can decline more than the standard flat bench position (also referred to as a body-building type of bench press).

![Fig 168](image)  ![Fig 169](image)

Shown below are examples of the standard flat bench (Fig 170) advocated by the fitness industry versus the competition bench position arch (Fig 171).

![Fig 170](image)  ![Fig 171](image)

Various views are necessary to show the bottom (chest) position which may be altered accordingly.
Why the extensive review on the planes of motion in relation to the glenohumeral joint? This is necessary due to the many explanations of the bench press in the training industry (particularly from the powerlifting community) that eliminates any specific reference to which joint(s) is/are involved as well as which plane(s) of motion this movement moves through. Many explanations exist on “how” a particular individual or group performs this movement but no in-depth analysis seems to exist to show the “why this movement should be performed in a particular fashion.” The “why” includes the planes of motion the bench moves in (“why” there is a designated primary plane movement) based on the joint(s) involved, muscle activity as well as why the shape of the primary mover(s) facilitates this movement. The “why” also factors in the individual’s unique variables i.e. length of segments, ROM at a specific joint, bone structure/formation differences, etc.

The bench press has both dynamic and static actions. The dynamic action is at the shoulder joint and at the elbow joint. The actual shoulder girdle, particularly the scapula and clavicle, along with the remainder of the body (trunk and lower extremities), are static (non-moving).

Our next section is a detailed analysis of how the muscles involved with the shoulder girdle work to facilitate performing the bench press. The primary focus will be on the muscles that move the arm at the shoulder joint through the planes of motion.

Major Musculature of the Shoulder Girdle

The muscles involved in the various motions of the shoulder girdle (all sections) are:

- Pectoralis Major and Minor
- Deltoid (three sections)
- Trapezius (four sections)
- Rhomboids (Major and Minor)
- Levator Scapula
- Latissimus Dorsi
- Teres Major
- External Obliques
- Rotator Cuff (4 muscles: supraspinatus, infraspinatus, teres minor, subscapularis)

In addition to these we have muscles that facilitate movement at the elbow joint

- Biceps (all sections particularly the bicep brachii which crosses the shoulder joint)
- Triceps (all sections to include the long head which crosses the shoulder joint)

The shoulder girdle performs six major movements:

- Upward/Downward rotation
- Protraction/Retraction
- Elevation/Depression

Six major movements can be performed independently from movement at the shoulder joint. Therefore, for the bench press, once the lifter has set themselves up to perform the movement, the primary dynamic action is at the shoulder joint. Therefore we will focus on the muscles that move the arm since it is attached at the SJ (the glenoid fossa and humeral head). The remainder of the shoulder girdle (scapula and clavicle) is fixed during the bench press movement.
Movements at the Shoulder Joint

First we begin with the anatomical neutral position. We begin here since all movement is based on and referenced from this position.

Next we must look at how the muscles are positioned related to the shoulder joint to cause movement. The muscles that cause movement at this multi-axial/multi-planer joint are:

- Pectoralis major
- Deltoid (all sections)
- Latissimus Dorsi
- Teres Major
- Coracobrachialis
- Rotator Cuff (4)

From the anatomical neutral position we start with motions in the sagittal plane and the muscles causing these motions then move on to the other planes (to include multi-planer movements). A simple and direct way to view all these actions is making a chart describing each motion/plane of motion, shoulder joint agonist, shoulder girdle actions, and shoulder girdle agonists.

<table>
<thead>
<tr>
<th>Shoulder Joint Action and Plane of motion</th>
<th>Shoulder Joint Agonists</th>
<th>Shoulder Girdle Actions</th>
<th>Shoulder Girdle Agonists</th>
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<tr>
<td>Flexion (Sagittal Plane)</td>
<td>Anterior Deltoid, Upper Pectoralis Major (clavicular section), Coracobrachialis</td>
<td>Elevation/Upward Rotation</td>
<td>Levator Scapulae, Serratus Anterior, Upper and Middle Trapezius (2 and 3), Rhomboids</td>
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<tr>
<td>Extension (Sagittal Plane)</td>
<td>Latissimus Dorsi, Teres Major, Lower Pectoralis Major (Sternal Section), Posterior Deltoid</td>
<td>Depression/Upward Rotation</td>
<td>Pectoralis Minor, Lower Trapezius (4)</td>
</tr>
<tr>
<td>Abduction (Frontal Plane)</td>
<td>Supraspinatus, deltoit, upper pectoralis major (clavicular portion)</td>
<td>Upward Rotation/Elevation</td>
<td>Serratus Anterior, Middle/Lower Trapezius, Levator Scapulae, Rhomboids</td>
</tr>
<tr>
<td>Adduction (Frontal Plane)</td>
<td>Latissimus Dorsi, Teres Major, Lower Pectoralis Major (Sternal Section)</td>
<td>Downward Rotation</td>
<td>Pec Minor, Rhomboids</td>
</tr>
<tr>
<td>Horizontal Abduction (Transverse Plane)</td>
<td>Middle and Posterior Deltoids, Infraspinatus, Teres Minor</td>
<td>Adduction (Retraction)</td>
<td>Middle and Lower Trapezius, Rhomboids</td>
</tr>
<tr>
<td>Horizontal Adduction (Transverse Plane)</td>
<td>Pectoralis Major, Anterior Deltoid, Coracobrachialis</td>
<td>Abduction (Protraction)</td>
<td>Serratus Anterior, Pectoralis Minor</td>
</tr>
<tr>
<td>Diagonal Abduction Multi-planer Movements (Overhead Activities)</td>
<td>Posterior Deltoid, Infraspinatus, Teres Minor</td>
<td>Adduction (Retraction)/Upward and Downward Rotation</td>
<td>Trapezius, Rhomboids, Serratus Anterior, Levator Scapulae</td>
</tr>
<tr>
<td>Diagonal Adduction Multi-planer Movements (Overhead Activities)</td>
<td>Pectoralis Major, Anterior Deltoid, Coracobrachialis</td>
<td>Abduction (Protraction)/Depression and Downward Rotation</td>
<td>Serratus Anterior, Pectoralis Minor</td>
</tr>
</tbody>
</table>

The shape of the pectoralis major has a substantial impact on the movements performed at the shoulder joint. Remember this joint is considered multi-axial/multi-planer. The shape of the muscle and the arrangement of the fibers [line of pull of these fibers] has a direct influence on the plane of motion, the angle of movement through any designated plane (to include a diagonal motion across all planes) as well as what type of movement is being performed through a specific plane of motion. With the shoulder joint being multi-planer the pectoralis muscle is considered a triangular or convergent shape muscle. The picture below notes the two major sections as well as the angle of all the fiber bundles in the pectoralis major.
Please note the **insertion** of the pectoralis on the humerus. (Note arrow). The insertion is inverted, i.e. the clavicular fibers are on the bottom of the insertion point with the sternal fibers underneath and above the clavicular. This design is specific for this multi-planer joint to recruit different sections of the pec muscle based on the angle of the arm during movement. Also note the angle of the fibers coincide with the insertion point and muscle shape.

Here is another view of the inverted insertion tendon for the pectoralis major.

The below pictures depict the angle of pull of these fibers. As stated before each time the angle of the arm changes during movement the sectional fibers will change/recruited accordingly. The entire pectoralis major muscle is working but the section of the pec muscle being emphasized is dependent on the angle of the arm action. This is referenced in different types of bench press movements e.g. incline/flat/decline presses.

Below is another view to further clarify the differences between each section of the pectoralis to show the fibers and their specific angles of pull with the arm abducted to 90°. If one were doing a flat bench press with the arms positioned at a 90° angle from the body, bar coming to the upper portion of the sternum, the upper fibers (clavicular portion) will be pulling directly in line with the arm. Changing the angle of the arm, as well as internally rotating the arm, one can directly activate and recruit various sections of the pectoralis. Please also note the entire pectoralis is working but the portion of the muscle directly opposing the action of the movement.
Example: Machine Decline Bench Press (Portion “C” of fig 181)

**Eccentric Action**
Muscle shortening (concentric action) in line with moving the arms forward during the decline movement

**Concentric Action**
Muscle lengthening in line with moving the elbows rearward in the eccentric action in the decline movement

Fig 182

Fig 183

Notice normal lordic curve along with where the bar may be placed on the chest (middle portion). This indicates the middle sternal fibers are activated due to the bar position and lack of a “arch” to position the chest to a more decline-like position

Fig 184

The arms are placed at a 90° to the body. Bringing the bar down to the top of the chest will activate the clavicular portion of the pectoralis major independent of have an incline bench to utilize.

The lifter is using an incline bench (degrees of angle will vary considerably based on recommendations). Please note at this angle the bar will be brought down to the upper portion of the chest to activate the clavicular section of the pecs.
Deltoids

As previously stated, the deltoid is divided into three section with each having a distinct role.

Anterior – causes flexion of the arm in the sagittal and transverse plane (flexion is also called adduction in the transverse plane) depending on the position of the arm and if the fibers of that particular head are directly opposing/aligned with the external force.

Medial – if the fibers are opposing/ aligned correctly against the external load it will cause abduction in the frontal plane.

Posterior – if the fibers are aligned correctly against the external force it causes extension/ hyperextension in the sagittal plane as well as abduction in the transverse plane.

Elbow Joint and Associated Muscles

The elbow joint is the synovial hinge joint between the humerus in the upper arm and the radius and ulna in the forearm which allows the hand to be moved towards and away from the body. The superior radioulnar joint shares joint capsule with the elbow joint but plays no functional role at the elbow. The elbow region includes prominent landmarks such as the olecranon (the bony prominence at the very tip of the elbow), the elbow pit, and the lateral and medial epicondyles.

The elbow joint has three different portions surrounded by a common joint capsule. These are joints between the three bones of the elbow, the humerus of the upper arm, and the radius and the ulna of the forearm.

<table>
<thead>
<tr>
<th>Joint</th>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humeroulnar joint</td>
<td>trochlear notch of the ulna</td>
<td>trochlea of humerus</td>
<td>Is a simple hinge-joint, and allows for movements of flexion and extension only.</td>
</tr>
<tr>
<td>Humeroradial joint</td>
<td>head of the radius</td>
<td>capitulum of the humerus</td>
<td>Is a ball-and-socket joint.</td>
</tr>
<tr>
<td>Superior radioulnar joint</td>
<td>head of the radius</td>
<td>radial notch of the ulna</td>
<td>In any position of flexion or extension, the radius, carrying the hand with it, can be rotated in it. This movement includes pronation and supination.</td>
</tr>
</tbody>
</table>

When in anatomical position there are three main bony landmarks of the elbow. At the lower part of the humerus are the medial and lateral epicondyles, on the side closest to the body (medial) and on the side away from the body (lateral) surfaces. The third landmark is the olecranon found at the head of the ulna. These lie on a horizontal line called the Hueter line. When the elbow is flexed, they form an equilateral triangle called the Hueter triangle.
At the surface of the humerus where it faces the joint is the trochlea. The groove running across the trochlea is, in most people, vertical on the anterior side but spirals off on the posterior side. This results in the forearm being aligned to the upper arm during flexion, but forming an angle to the upper arm during extension — an angle known as the carrying angle.

Motion at the elbow is restricted to only flexion and extension. It is a uni-axial joint i.e a true hinge joint.

Elbow flexion:

- Brachialis acts exclusively as an elbow flexor and is one of the few muscles in the human body with a single function. It originates low on the anterior side of the humerus and is inserted into the tuberosity of the ulna.

- Brachioradialis acts essentially as an elbow flexor but also supinates during extreme pronation and pronates during extreme supination. It originates at the lateral supracondylar ridge distally on the humerus and is inserted distally on the radius at the styloid process.

- Biceps brachii is the main elbow flexor but, as a biarticular muscle, also plays important secondary roles as a stabiliser at the shoulder and as a supinator. It originates on the scapula with two tendons: That of the long head on the supraglenoid tubercle just above the shoulder joint and that of the short head on the coracoid process at the top of the scapula. Its main insertion is at the radial tuberosity on the radius.

Elbow extension:

- Simply bringing the forearm back to anatomical position.

- This action is performed by triceps brachii with a negligible assistance from anconeus. Triceps originates with two heads posteriorly on the humerus and with its long head on the scapula just below the shoulder joint. It is inserted posteriorly on the olecranon.

- Triceps is maximally efficient with the elbow flexed 20–30°. As the angle of flexion increases, the position of the olecranon approaches the main axis of the humerus which decreases muscle efficiency. In full flexion, however, the triceps tendon is “rolled up” on the olecranon as on a pulley which compensates for the loss of efficiency. Because triceps’ long head is biarticular (acts on two joints), its efficiency is also dependent on the position of the shoulder.

- Extension is limited by the olecranon reaching the olecranon fossa, tension in the anterior ligament, and resistance in flexor muscles. Forced extension results in a rupture in one of the limiting structures: olecranon fracture, torn capsule and ligaments, and, though the muscles are normally left unaffected, a bruised brachial artery.

Primary Function

- The function of the elbow joint is to extend and flex the arm grasp and reach for objects.[14] The range of movement in the elbow is from 0 degrees of elbow extension to 150 of elbow flexion.[15] Muscles contributing to function are all flexion (biceps brachii, brachialis, and brachioradialis) and extension muscles (triceps and anconeus).

- In humans, the main task of the elbow is to properly place the hand in space by shortening and lengthening the upper limb. While the superior radioulnar joint shares joint capsule with the elbow joint, it plays no functional role at the elbow.

- With the elbow extended, the long axis of the humerus and that of the ulna coincide. At the same time, the articular surfaces on both bones are located in front of those axes and deviate from them at an angle of 45°. Additionally, the forearm muscles that originate at the elbow are grouped at the sides of the joint in order not to interfere with its movement. The wide angle of flexion at the elbow made possible by this arrangement — almost 180° — allows the bones to be brought almost in parallel to each other.
For the bench press:

- Once the hand width and body are set (proper chest angle), the bar is lifted out to the lifter.
- The bar is brought out over the middle of the chest.
- The shoulder girdle is set (depressed and retracted). This helps align the elbows and hands to directly oppose the external line of force (no elbow tuck which causes external rotation).
- Position of the chest remains at a semi-decline angle and back arched accordingly.
- Feet flat are on toes.
- Super-stiffening (stabilize spine).
- Bar path is curved down to the position on the chest.
  - Position is a point of contention due to the various categories of lifting.
  - Top of abdominals?
  - Just below nipple line/base of pecs?

![Bar over middle of chest](image1.png)

Scapula retracted/depressed
Elbows/hands aligned in line with external line of force

![Fig 193](image2.png)

Bar path is curved down to the position on the chest:

- Position is a point of contention due to the various categories of lifting.
  - Top of abdominals?
  - Just below nipple line/base of pecs?

![Push off chest](image3.png)

- Pecs start movement with transverse adduction.
- Front delts assist but movement at shoulder joint is rotary therefore bar path rotates slightly toward shoulder.
- Once past sticking point the elbows extend in conjunction with the path of the shoulder joint.

![Fig 195](image4.png)

Two images of the bar path:

![Fig 196](image5.png)

- Bottom of chest remains motionless
  - Super-stiffening maintained
  - Depression of bar into chest then stop?
  - Elbows and hands stay aligned in vertical line.

![Fig 197](image6.png)
Additional information/examples concerning bar path:

- **Pecs start movement starts movement**
  - then back slightly and up vertically.
  - Load is on the triceps and on the anterior deltoid since the bar is still away for the shoulder joint.

![Bar up and back but then continues to travel upward keeping the load on the triceps (extension) but away from SJ causing a larger moment arm.](Fig 198)

![Bar up and away from SJ causing an even larger moment arm.](Fig 199)

![Bar up and back. Pecs activated with anterior deltoid. Path is more natural causing the deltoid and triceps to work in conjunction. Finishing position has no moment arm on the SJ.](Fig 200)
Determining Grip Width for the Bench Press

- Use any dowel rod or PVC pipe
- Place hands on dowel rod or PVC pipe and place it at the base of the sternum (bottom of chest muscles)
- Adjust grip width to align hands and elbows
- Measure distance between hands (this will be your starting point to determine grip width for the bench press)

Starting Position

- Lie in a supine position on a bench in the 7-point body contact position.
  - Head, shoulders, gluteus, and both feet (flat on floor) or on balls of feet/tip of shoes (lifter preference)
  - There are many protocols to achieve an optimal thoracic position (back arch). The main point here is to position the chest into a pseudo decline position (back arched, top of scapula on bench).
- Place the body on the bench so that the eyes are below the racked bar.
  - This starting position allows adequate distance from the bench uprights. Eyes behind the bar may position the body too close to upright. Being too close to upright may interfere with the bar path (pushing the bar upward may strike the standards)
- Grasp the bar with a closed, pronated grip
  - Initial grip width determined by the Bench Press Measurement Protocols
  - NOTE: the lifter may use the maximum grip width (81 cm/32 inches)
    3.0.1 Having a wide grip should be used with caution
    3.0.2 This type of grip is considered a more advanced benching technique
    3.0.3 If a wide grip is desired, it is recommended to move grip out slowly to allow the shoulder joint connective tissue to adapt
    3.0.4 A grip with a narrower grip can cause the pectoralis to become more of an assistance mover since it will move into the sagittal plane.
    3.0.1.1 CAUTION: Please note much of these protocols come from geared lifting and are not applicable to raw lifters.
- Signal the spotter for assistance in moving the bar off the supports.
  - Spotter should assist the “lift out” of the bar after the lifter has set up properly.
  - Spotter should not lift bar too high off the standards (lift the bar out to facilitate the lifter maintains their taut position.
    - Spotter should lift the bar up slightly then out to position the bar over the chest desired by the lifter.
    - Once the bar is positioned, spotter releases their grip slowly with a controlled descent to ensure the lifter accepts control of the weight.
**Downward Movement Phase**

- Once bar is in place, the lifter depresses and retracts scapula (lifter should maintain fixed shoulder girdle position).

- With hands gripped tightly, inhale deeply (active diaphragm) to increase inter-abdominal pressure (super-stiffening).

- Lower the bar under control. Do not lower the bar too slowly (this increases energy expenditure and may fatigue lifter).

- Touch the chest just below the nipple level or at the base of the sternum. *

- Keep the wrists stiff and the forearms perpendicular to the floor and parallel to each other (in line with external line of force).

- Maintain the 7-point body contact position.

**Upward Movement Phase**

- Push the bar upward explosively until the elbows are fully extended (Impulse/mRFD).
  - Shoulder blades retracted.
  - Attempt to “extend” legs simultaneously.

- Keep the forearms perpendicular to the floor and parallel to each other.

- Bar path may be straight up or move slightly rearward toward the eyes.
  - There are differences of opinion as to path of bar.
    - Straight up or push back slightly over eyes.
    - Mechanics show less stress on the shoulder and better muscle synchronization with bar path up and back slightly.

- Extend the elbows until they are locked. Stop the movement and hold.

- Maintain the 7-point body contact position.

- At the end of the set, signal the spotter for assistance in racking the bar.

- Keep a grip on the bar until it is racked.

**Bench Press Finish Position**

Note: attempt to pull shoulder blades together tighter and raise the chest as you lower the bar!

NOTE: Some federations allow lifter to be up on “toes” which does not allow the lifter to extend legs.
Certified Powerlifting Instructor

Skill Performance Procedures

**Goal Evaluations**
- Increase upper body pushing strength (transverse plane)

**Skill Selections**
- Wide grip barbell bench press

**Description**
- 7 Points of contact (scapula, glutes, feet)

**Preparation**
- Align eyes with bar
- Grip width adjustment
- Have bar handed off (base of sternum) - wrists straight
- Depress and retract scapula (set shoulder girdle)
- Inhale deeply (fill lungs and belly with air) and hold
- Foot position (width of stance, under /behind knees)

**Execution**

**Descent**
- Lower bar to chest (moderate speed)
- Scapula squeezed and depressed tightly
- Path of motion /plane of motion/line of force
- Hands/elbows aligned (path of motion aligned properly)
- All point of contact maintaining contact
- Touch bar to the individual's preference

**Ascent**
- Reverse movement explosively (high impulse/mrfd)
- Extend legs/scapula remains etracted/depressed
- Attempt to accelerate bar (path is straight up)
- Elbows always in line with hands throughout motion
- Adjust speed of bar as you extend /lock elbow

**Recovery**
- If one rep re-rack bar
- If multiple reps ensure prep position maintained

**Observation**
- 7 Points of contact
- Start position (scapula retract/depressed)
- Super -stiffening (trunk i.E. Holding breath)
- Elbows /hands aligned during descent/ascent
- Speed/path of bar motion – descent verses ascent
- Recovery
- **Evaluation** – optimal position/flaws throughout entire motion
- **Instruction** – individualization of optimal style of technique
References


Valmassy, R. *Clinical Biomechanics of the Lower Extremity. Color Atlas of the Foot and Ankle Anatomy*. 2nd ed. Philadelphia, PA: Saunders. 1996. Dr. Brandon J. Hawkins DPM, CWS, FACLES Dr. Hawkins is owner/ partner of Stockdale Podiatry Group and Sequoia Foot Care Group. He is the chief of Podiatry at Bakersfield Heart Hospital and serves on many University boards and national boards including the International group the Association for the Advancement in Wound Care.Ci dolllorum adi coresto et erciis reperis inversp eribusa vollant.