ADVANCED PULL MECHANICS *(for Olympic weightlifters)*

Edward W. Herger

1) *Explosive techniques*

For those who are true practitioners of the Olympic lifts, it is well known that these are among the most technically intense of all athletic events. True explosiveness is not simply the result of rapid, high strength muscle contraction. Explosiveness is the result of properly setting up and executing a series of dynamic mechanical events of escalating kinetic energy levels.

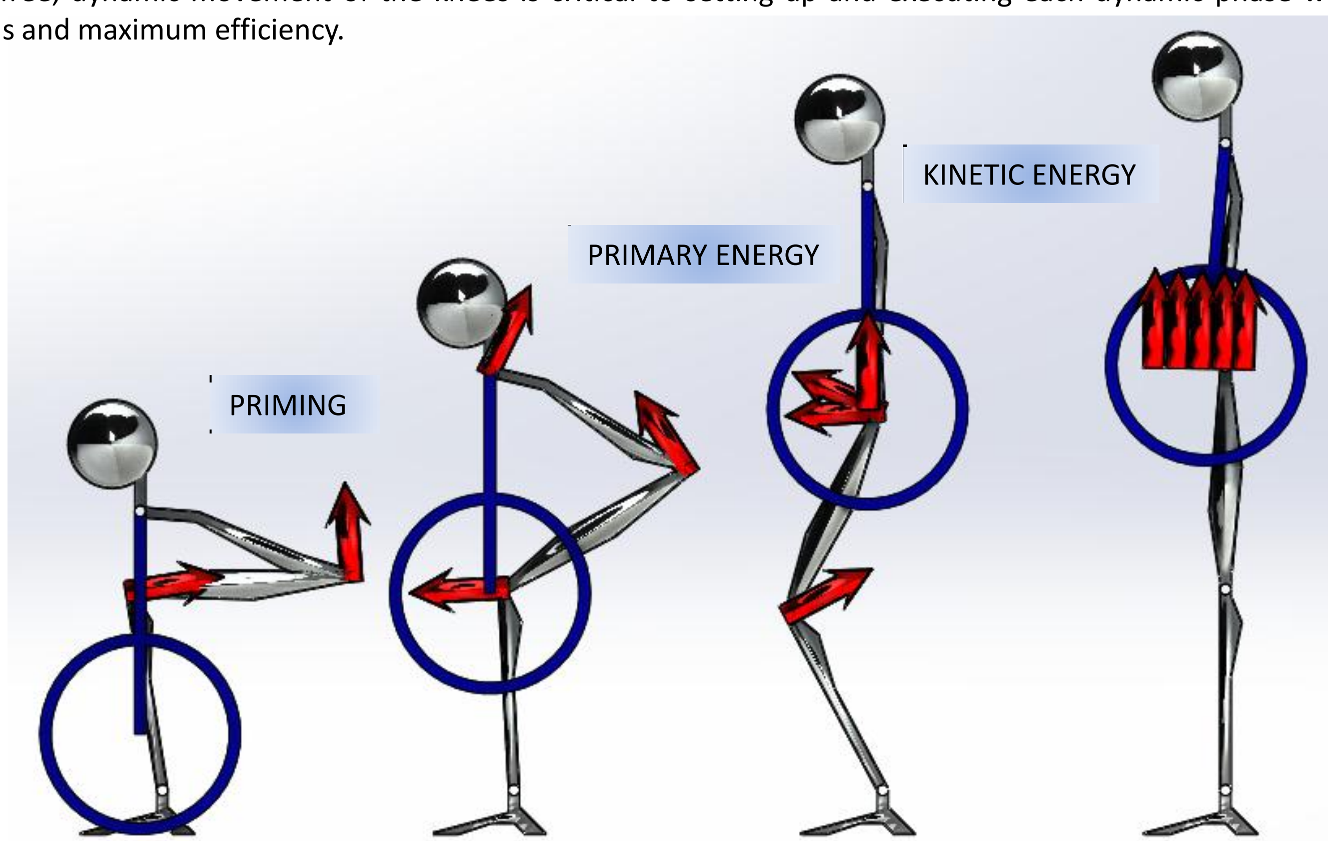
2) 3 Dynamic phases

The snatch pull and the clean pull both consist of 3 separate phases. Each phase involves an increasing amount of kinetic energy added to the bar through a unique energy based mechanism.

Phase 1: *Priming Phase*
Phase 2: *Primary Energy Phase*
Phase 3: *Kinetic Energy Phase*

3) Active knee modulation

Each of the 3 dynamic phases is based upon the positioning, transitioning and motion of the knees. Allowing free, dynamic movement of the knees is critical to setting up and executing each dynamic phase with smooth transitions and maximum efficiency.



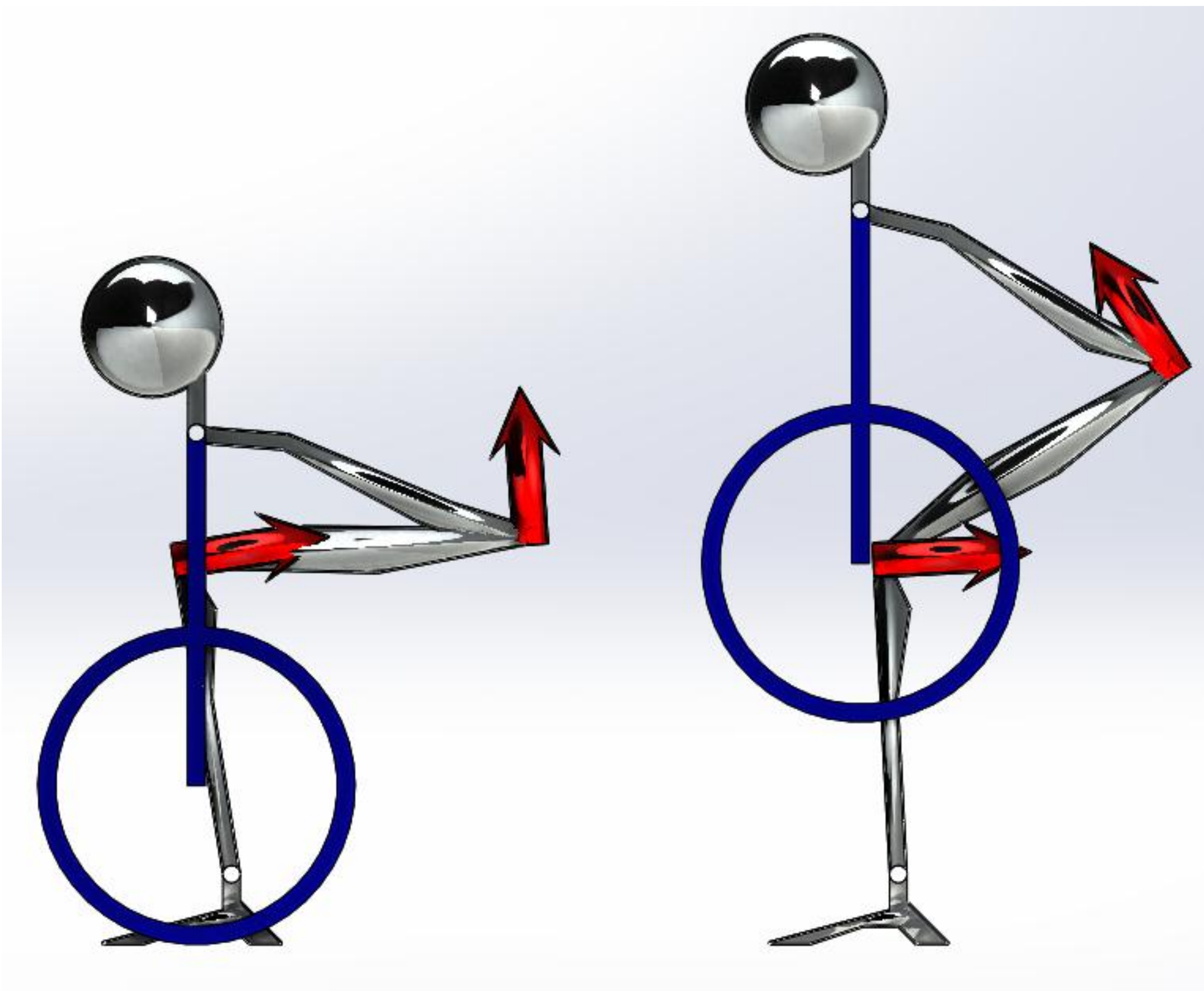
Briefly review the 4 distinct transitional positions of the pull; red arrows represent influential energy additions to the system as the mechanism progresses. Energy remains in the system and builds unless loss occurs due to poor execution.

4) Priming phase

In the priming phase, the bar is accelerated to a moderate vertical speed (nominal kinetic energy) continuing until it reaches knee level. Rigidity of the spine and upper back is critical throughout, and is initiated in this phase.

As the bar rises, the knees move backward allowing the bar to pass cleanly, but without creating significant distance between the shin and the bar.

Once the bar is at knee level, a large angle between the thighs and the torso exists. This primes the body to accelerate the bar using a long range contraction of the spine erectors, gluteus and hip adductors.



The start is initiated by backward knee motion and continues with a long angular sweep of the thigh around the knee. This mechanism relies upon leverage (large body movement for small bar movement) and is therefore mechanical in nature. The motion continues to the first knee transition. At this point, the bar will have a small but important amount of kinetic energy allowing the body to transition without stalling or hitching during a brief bar deceleration at the transition.

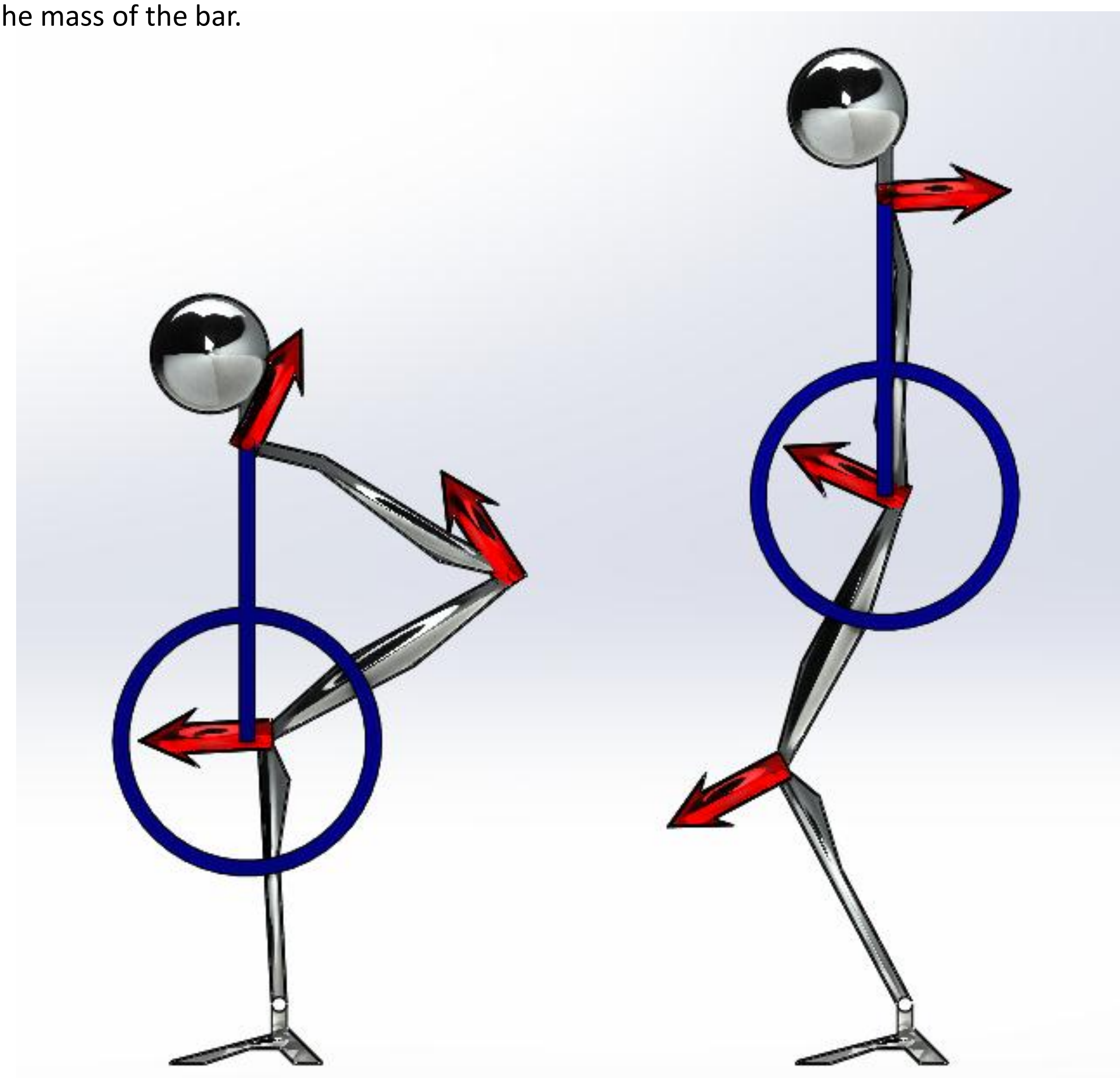
5) Primary energy phase

The primary energy phase is initiated by the first knee transition (backward movement to forward movement). Large amounts of mechanical energy are generated by the contraction of the spine erectors, gluteus and hip adductors rotating the torso over a large angle around the hips. This is a large energy addition to the system, note however that the mass of the body is gaining kinetic energy as well as the mass of the bar.

Knee movement is forward in order to provide a solid platform to support the large vertical forces that exist during this phase. The movement of the knee also causes the bar to “brush” the thigh which is critical when transitioning to the kinetic energy phase.

Significant acceleration of the bar occurs. The bar gains speed (kinetic energy) in proportion to the body’s gain of speed (kinetic energy). This is a mechanically efficient process of converting mechanical energy to kinetic energy.

As the bar nears the height of the hips, a significant change in mechanics is occurring. The vertical speed of the bar is quickly catching up to the overall vertical speed of the body. This dictates that additional vertical pulling effort will become increasingly inefficient. The kinetic energy phase will now begin allowing the kinetic energy of the body mass to transfer into the mass of the bar.



Knee movement starts forward initiating a very long and powerful angular sweep based in the knees and focused at the hips. Energy is added in a largely vertical direction yielding very high efficiency in transferring kinetic energy to the bar. As this phase progresses, energy addition in the vertical direction is becoming less efficient. The bar contains a large amount of vertical kinetic energy at this point. However, the body contains a large amount of kinetic energy at a shallow angle to the horizontal. Transition begins as the bar physically locks into place against the hips/upper thigh.

6) Kinetic energy phase

In the kinetic energy phase, the second knee transition (forward movement to backward) occurs allowing a rapid, direct kinetic energy transfer; not vertically through the arms, but by direct contact at the hips/upper thigh.

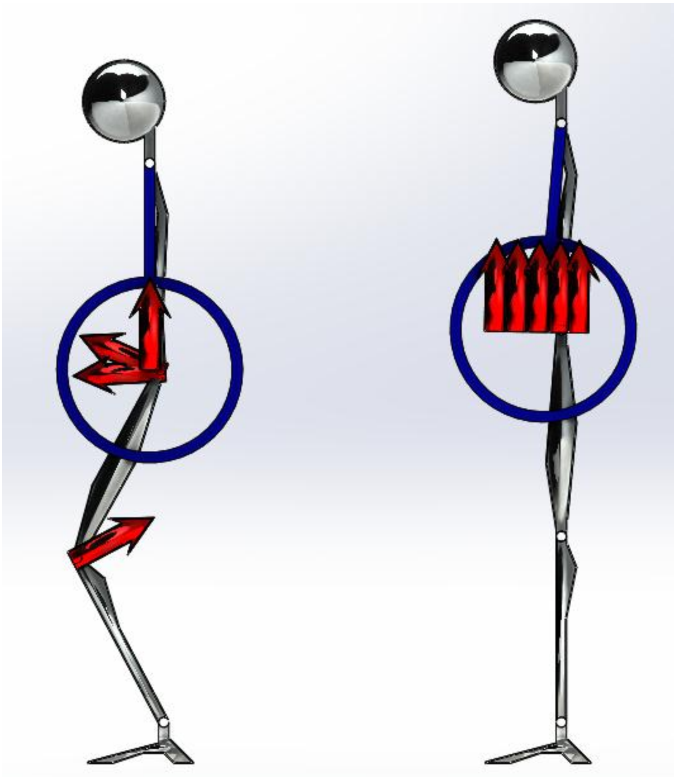
6a) Nonlinear energy gain

During this phase, the body is rapidly straightening. The hips accelerate violently forward and the knees backward in a fleeting effort to continually lift the shoulders upward. Mechanical energy efficiency is poor because the driving movements are now nearly perpendicular to the desired vertical direction of movement. However, kinetic energy at the hips is growing disproportionately high. "Nonlinear" is the scientific term given to an extreme acceleration caused by the conditions of a mechanism, a whip effect. If the hips are allowed to reach very high speed, efficiency will be sacrificed and large amounts of energy will be absorbed by the body structure. This inefficiency must be avoided.

A synergistic nonlinear effect occurs simultaneously: an extremely large amount of force also becomes available in the direction of hip movement as the body straightens. This is also caused by conditions of the mechanism since the muscle contraction rotating the torso is becoming perpendicular to the direction of motion. The combination of high velocity and high force generation results in an exceptionally high power condition focused at the hips.

6b) Full contact energy transfer

To complete the kinetic energy phase efficiently, the nonlinear energy gain **(explosion)** is transferred to the bar by direct contact at/near the hips. With proper positioning at the second knee transition, the bar will physically lock into the hips or upper thigh before hip speed becomes excessive. The final knee movement and complete straightening of the body can now occur with the lifter's maximum effort being managed efficiently by the mass of the bar. As the mass of the bar manages the explosion of the body by full physical contact, the bar directly receives all of the energy produced by the lifter with very high efficiency.



With the bar firmly set against the hips/upper thigh, the second knee transition begins as the knee rapidly moves backward to balance the forward snap of the hips. The body's extremely high energy state is efficiently transferred to the bar. This explosive event serves to both increase the vertical speed of the bar, and to arrest the momentum of the body to allow a superior transition to the catch.

7) Exokinetics

Exokinetics is the sports practice of using the body to develop kinetic energy, focus kinetic energy and deliver all or most of the kinetic energy to an external object such as a barbell. For perspective, consider a squat, this technique is purely mechanical in that the bar obtains little kinetic energy and has none once the squat is complete, it remains at rest on the shoulders. Now consider a 100 meter sprint, this action is kinetic, the mass of the body develops a large amount of kinetic energy, but never focuses the energy toward an external object. The pull of a snatch or clean is exokinetic. This is made clear by one simple but often overlooked condition: the speed of the body reaches zero at the very top of the pull while the bar continues upward with its maximum speed.

The Olympic lifts fall into this rather broad category of sports techniques in which the athlete intends to impart the maximum possible amount of kinetic energy to an external object. As a condition of the technique, the kinetic energy remaining with the athlete's body is either unimportant, or more likely is required to be very low in order to maintain control for a subsequent part of the technique. In the lifts, the subsequent technique is to reverse the direction of the body in preparation to catch the barbell. Since kinetic energy remaining with the body will move the body in undesirable directions, proper exokinetic execution of the pull in a snatch or clean is highly advantageous in terms of power, efficiency, repeatability, safety and overall successful completion of the attempt.

Exokinetic techniques consist of 3 phases which were described above in detail for the lifts.

In general:

Phase 1 sets up a driving contraction of large muscle groups about the hips in order to generate maximum mechanical energy

Phase 2 initiates and accelerates the drive whilst establishing kinetic energy in the entire system

Phase 3 creates the kinetic energy path that transfers the nonlinear energy gain at the peak of the drive to the external object efficiently

Olympic lifting is unique as a speed based sport that deals with masses that are significantly larger than the mass of the athlete. Many sports require that the kinetic energy path travels from the ground (zero energy point), through the hips, then core, upper body, arm and hand to an external object. In the lifts, the kinetic energy path travels from the ground straight to the hips which are already in direct contact with the external object. This scenario leads to very high efficiency of energy transfer to the bar and, because all of the body's kinetic energy transfers to the bar, serves to arrest the body's speed at the top of the pull allowing a faster and more consistent transition to the catch position. In the Olympic lifts, improper exokinetics will either leave the bar without enough vertical speed to complete the lift or will leave the body with an unwanted forward velocity of the hips. Successful application of exokinetics eliminates very significant variables that will lead to poor efficiency and inconsistent lifting.

8) Summary of mechanics

- The purpose of the pull is to deliver enough kinetic energy to the barbell that it will continue upward upon completing the pull, eventually reaching a height at which it can be caught overhead (snatch) or on the shoulders (clean). Adding weight increases the required energy as does increasing the height such as during a power clean or snatch.

- The body generates energy by contracting muscle against a load over a range of motion. Increasing the load placed against the muscle and increasing range of motion both increase the amount of energy produced.

- Loss of energy continuously occurs while executing the pull. Sudden changes in the load against the contracting muscle groups are responsible for the majority of the loss. Smooth transitioning, proximity of the bar to the legs, solid back position and straight arms all prevent sudden changes in muscle loading which cause energy loss.

- Geometry dictates that the muscles of the lower body cannot be loaded by the weight of the bar hanging on the shoulders as the lifter reaches the top of the pull. To continue producing energy, the lifter now transitions to loading the muscles by contacting the bar at the hips.

- The greatest possible energy output occurs at the top of the pull once the bar has established full contact at the hips or upper thighs. If the bar has not smoothly established contact, a large amount of energy will be inefficiently lost.

- Energy lost at the top of the pull will not only reduce the final height that the bar reaches, but this energy will also influence the body in undesired ways as the transition to the catch begins.

- Proper ***Exokinetic*** execution increases both energy produced and energy delivered to the bar, and also reduces unpredictable energy influences at the critical transition to the catch.