Muscular Implications in Squat Exercises with the Russian Belt

by
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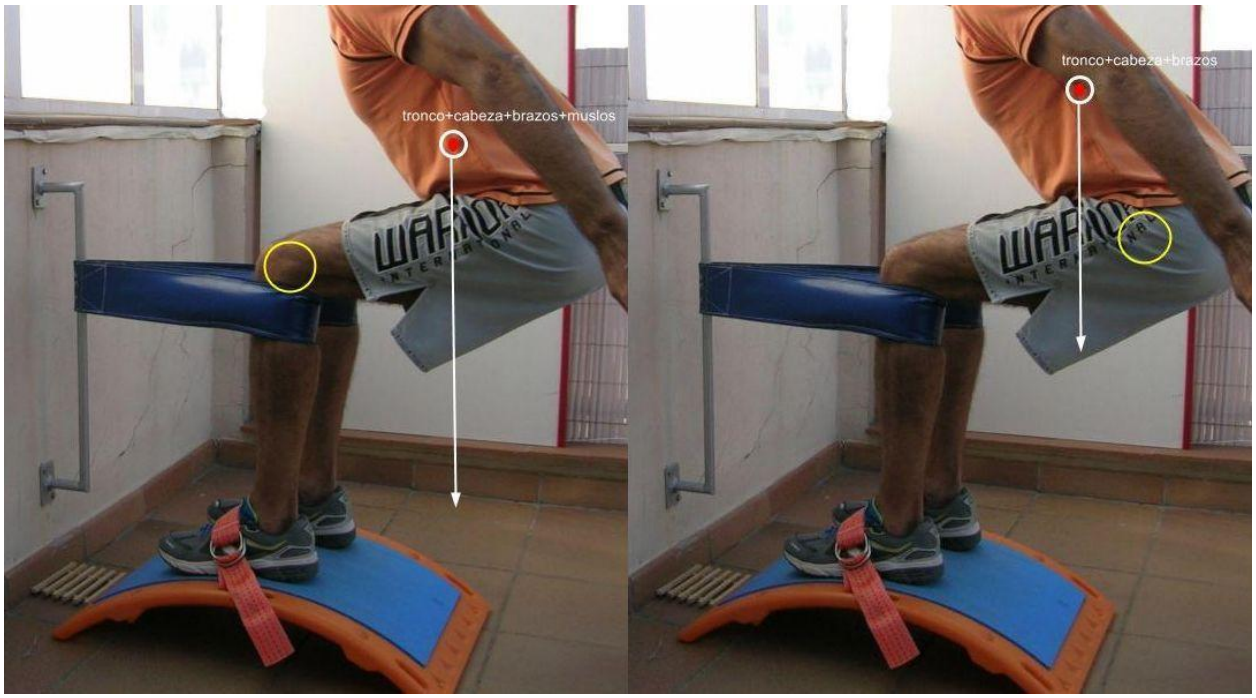
with the review of J Dapena (emeritus professor of sports biomechanics at Indiana University, USA)

During the execution of the squat or squat exercises with the Russian belt TMR, the position of the body segments varies the moments of force (clockwise and counterclockwise) that are exerted on the joints of the hip and knee. These moments of force can be overcome, balanced or not balanced by the forces of the respective muscles acting at each joint. In this way, in each static posture or during each phase of the movement, the specific biomechanical situation requires a differential and selective recruitment of the muscles.

Focusing on the muscular implications in relation to the hip and knee, the study is limited to muscle activity prediction methods for static or almost static situations (not valid when there are medium and large accelerations that require a more complex biomechanical analysis). To investigate the moments of force of the hip muscles, the position of the center of gravity of the trunk+head+arms system (*a) and the weight of this system must be taken into account; and to investigate the moments of force of the knee muscles, the position of the center of gravity of the trunk+head+arms+thighs system (*b) and the weight of this system must be taken into account.

(*) In the photos: a) tronco+cabeza+brazos (trunk+head+arms), and b) tronco+cabeza+brazos+muslos (trunk+head+arms+thighs).



The positions of the centers of gravity (red dots with white circles around them) of both systems have been calculated from the photo images; although they are not perfectly accurate because there are parts of the body that do not show completely well (such as the head). The arrows of the weight vector have also been drawn in proportion to the weights of the two systems. The trunk+head+arms system (used for hip calculations) accounts for 60% of the mass of the entire body. The trunk+head+arms+thighs system (used for knee calculations) accounts for 90% of the mass of the entire body (1.5 times greater than the previous one).

The analysis is developed differentiating three positions of the trunk:
(a) upright, (b) inclined, and (c) declined or extended backwards.

In the alternatives that are presented, it is considered that the hip is always kept with a certain anteversion that facilitates the maintenance of the healthy anatomical-physiological curvature of the spine.

The analysis of muscular implications is based on kinesiological knowledge and on the sensations experienced during training in the fields of motor physiotherapy and sports training; where apart from the variations of the type of execution and the possible additional overloads (such as free weights in different areas of the body), differences are experienced according to the levels of muscular balance and imbalance of each individual.

The biomechanical aspects are based on class notes taken from Professor Jesús Dapena (Dapena, J. (1994-1995). Class Notes on Mechanical Analysis of Human Performance. Kinesiology Department and Human Performance Labs of Indiana University at Bloomington) and on his exceptional teachings throughout all these years.

http://sportbiomechanics.com/

HIP MUSCLES

If the subject had his arms pointing laterally (Christ position in artistic gymnastics), a reference situation would be observed in which the center of gravity of the trunk+head+arms system would be aligned with the hip joint, with which the moment of force of the weight relative to the hip would be zero. Therefore, the muscles that pass anterior and posterior to the hip also do not need to exert any net moments of force. There may be no activation of these muscles, or there may be some activation of the anterior motor muscles (iliopsoas and quadriceps rectus femoris), but only if the posterior motor muscles (gluteus maximus-medius and hamstrings) are also simultaneously activated at a similar level.

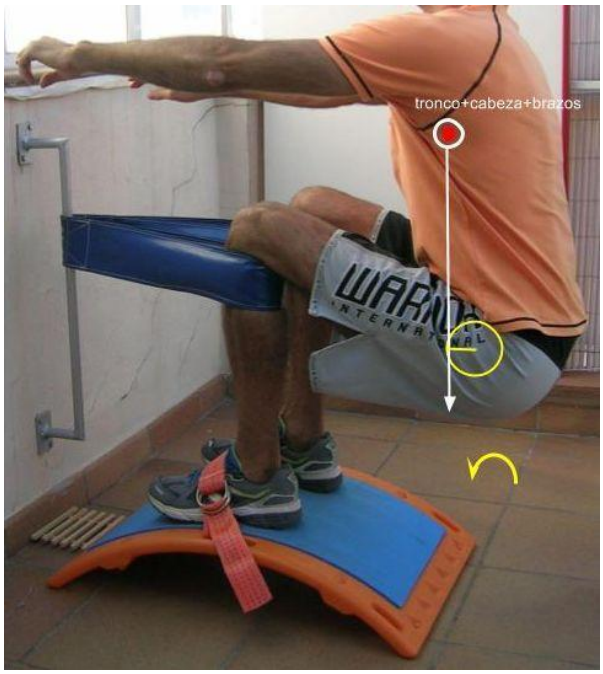
Actually, with the arms pointing forward, the center of gravity of the trunk+head+arms system is a little forward of the hip joint, so the weight creates a small counterclockwise moment of force in the body in relation to the hip, a moment of force that must be counteracted with an action of the posterior muscles of the hip (priority gluteus), with the anterior muscles in low postural tone, with the exception of the quadriceps rectus femoris, which, being biarticular, participates actively for knee extension, as we will see next.

KNEE MUSCLES

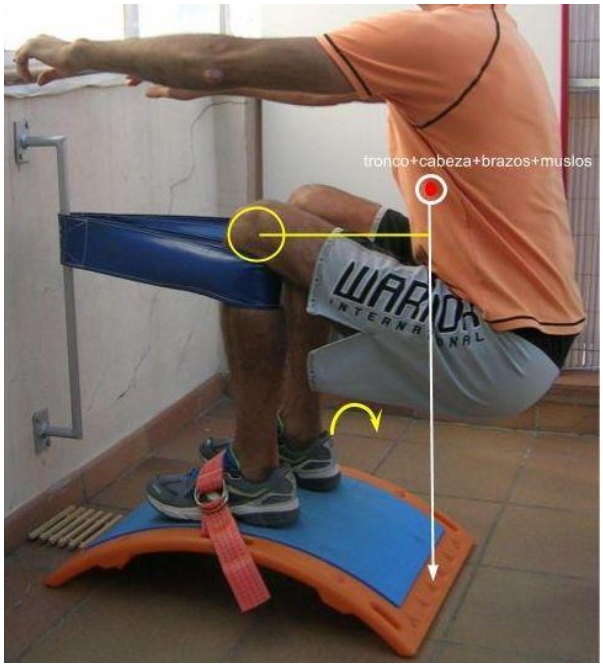
The weight of the trunk+head+arms+thighs system exerts an important moment of force in a clockwise direction in relation to the knee, which is counteracted by a counterclockwise muscular action of the quadriceps femoris muscles as the primary motor (vastus intermedius, lateralis and medialis, together with the less intense action of the rectus femoris).

The hamstrings in their retroverting action are in resting or pre-action postural tone.

VERTICAL TRUNK



Counterclockwise moment of force of the trunk+head+arms system in relation to the hip.



Clockwise moment of force of the trunk+head+arms+thighs system in relation to the knee.

HIP MUSCLES

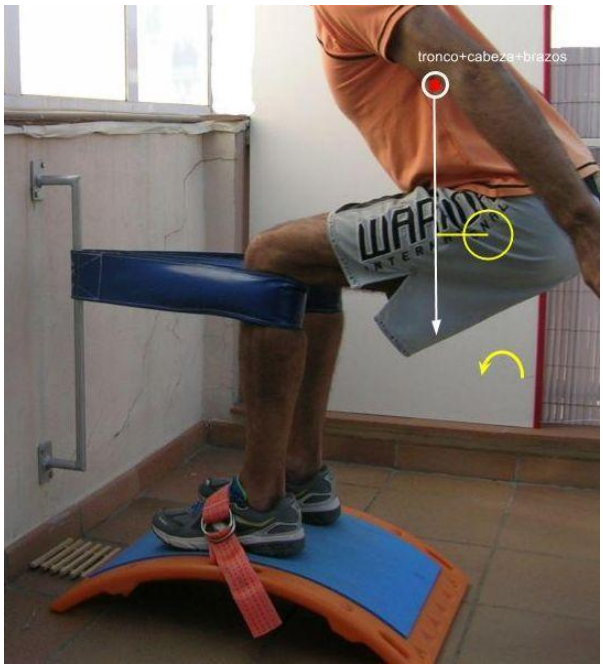
The greater the inclination of the trunk, the center of gravity of the trunk+head+arms system moves further forward of the hip joint; and thus a greater moment of force is created counterclockwise in relation to the hip, which must be compensated by recruiting the gluteus maximus-medius (main motor) and the hamstrings (in their retroverting function). The anterior muscles of the hip are in low postural tone, with the exception of the quadriceps rectus femoris, which, being biarticular, participates in knee extension.

KNEE MUSCLES

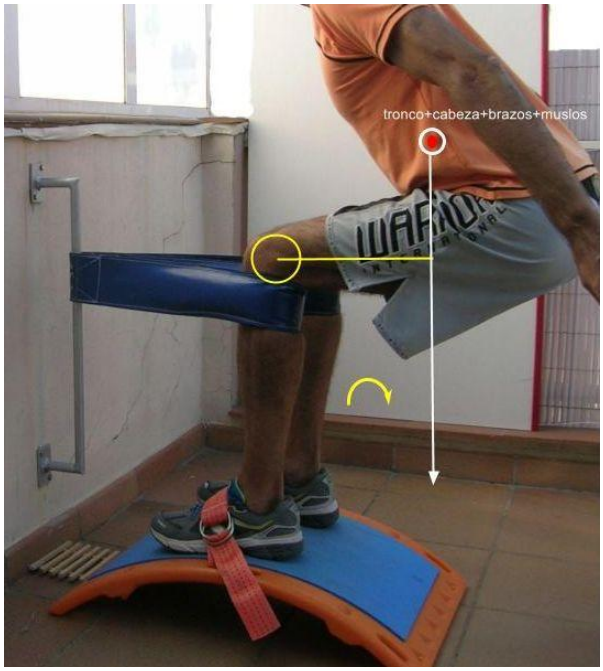
The greater the inclination of the trunk, the center of gravity of the trunk+head+arms+thighs system moves further forward and closer to the knee joint, creating a smaller moment of force clockwise relative to the knee. knee; which must be compensated with the anti-clockwise muscle action of the quadriceps femoris muscles as the primary motor (with relevance of the vastus intermedius, lateralis and medialis, together with the less predominant activation of the rectus femoris).

The hamstrings in their flexo-retroversion action are practically in postural tone without relevant participation; although with the trunk inclined, being more extended, its activation is greater than with the trunk vertical.

INCLINED TRUNK



Counterclockwise moment of force of the trunk+head+arms system in relation to the hip.



Clockwise moment of force of the trunk+head+arms+thighs system in relation to the knee.

HIP MUSCLES

The center of gravity of the trunk + head + arms system is well behind the hip joint, so a moment of force is created in a clockwise direction in relation to the hip that must be counteracted mainly with the actions of the hip iliopsoas and rectus femoris quadriceps, and to a lesser extent with the actions of the tensor fasciae latae and sartorius. A powerful action of the abdominal muscles is required (anterior rectus abdominis as the primary motor, the internal-external obliques as synergists, and the transversus as an accessory-stabilizer), whose work cannot be explained only with the mechanics of the hip.

This exercise may be appropriate for individuals with excellent abdominal muscle tone (for its pelvic retroverting action) that compensates for the powerful direct and bilateral action of the psoas on the lumbar vertebrae (in its lordotic or spinal straightening action in synergy with the paravertebral muscles) and indirect and accessory of the iliacus, sartorius, tensor fascia lata and rectus femoris of the quadriceps (in its anterior action of the pelvis).

KNEE MUSCLES

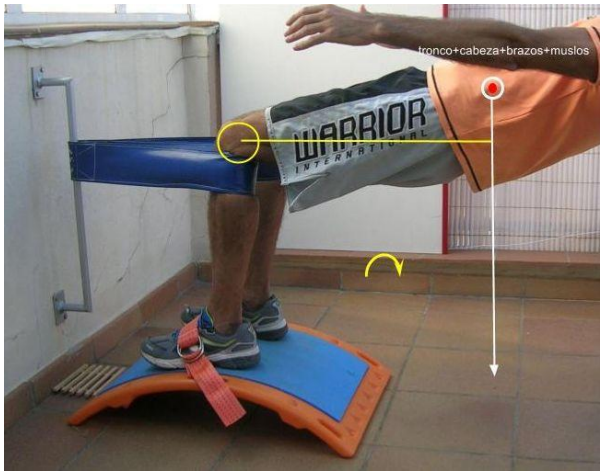
The center of gravity of the trunk+head+arms+thighs system is very far from the knee joint (greater the more horizontal the trunk is and the more the arms are extended behind), thus creating a very powerful moment of force in a clockwise direction in relation to the knee, which must be counteracted with the action of the quadriceps femoris muscles (as the primary motor and with a certain priority of the rectus femoris).

The biomechanics of this situation create great stress on the patellar tendon.

From the analysis of the two joints it is deduced that both the gluteus maximus-medius, hamstrings and lower back muscles are in the correct tension of postural tone.

DECLINED TRUNK OR EXTENDED BACKWARDS

Clockwise moment of force of the trunk+head+arms system in relation to the hip.



Clockwise moment of force of the trunk+head+arms+thighs system in relation to the knee.

SQUAT WITH ONE LEG

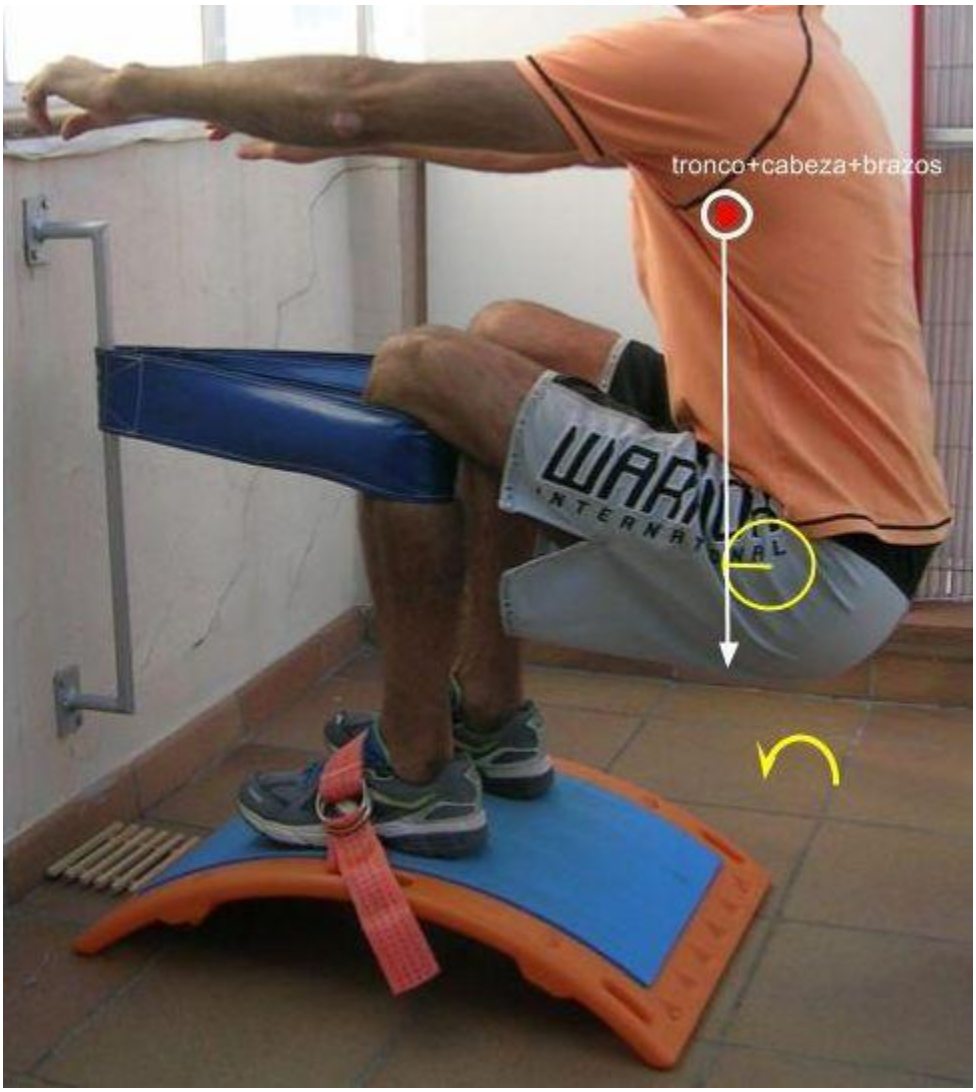
In the one-legged squat, the trunk+head+arms+leg-free system (80% of the total body mass) exerts a moment of force in relation to the hip and the trunk+head+arms+free-leg + left-thigh system (more than 94% of the mass of the entire body) exerts a very powerful moment of force in relation to the knee. These moments of force are counteracted with the musculature of the hip and of the performing leg, so this exercise is highly demanding on the muscles; especially in relation to the knee, where the moment of force created by a very high relative body mass must be overcome. A vertical or backward trunk position together with greater knee flexion moves the center of gravity away from the system and dramatically increases the moment of force to be overcome by the knee muscles.

The musculature involved in the one-legged squat action is very similar to that recruited in the two-legged squat; although it requires a much greater muscular requirement and an additional load on the lateral stabilizing muscles of the hip and knee; by having to maintain balance and counteract the weight of the system with a single leg performer.

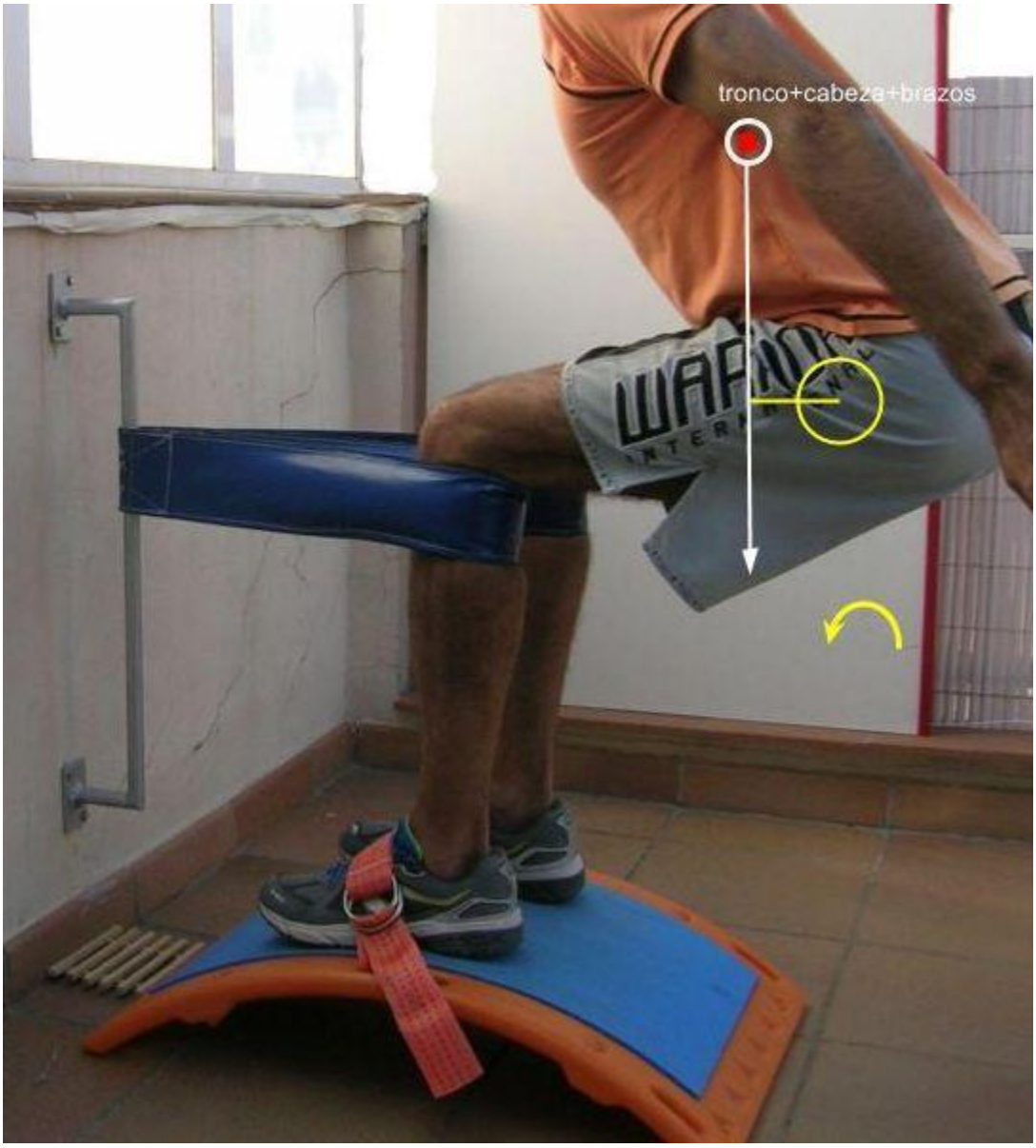
The main well-balanced foot stance options for the one-legged squat are: (a) horizontal stance and (b) decline stance.
With the foot in a declined plane, there is a preferential inhibition of the triceps surae, especially its biarticular muscles: the two gastrocnemius muscles and the plantaris (with very limited functionality, if any). It is especially indicated to prevent or treat injuries of the anterior cruciate ligament.

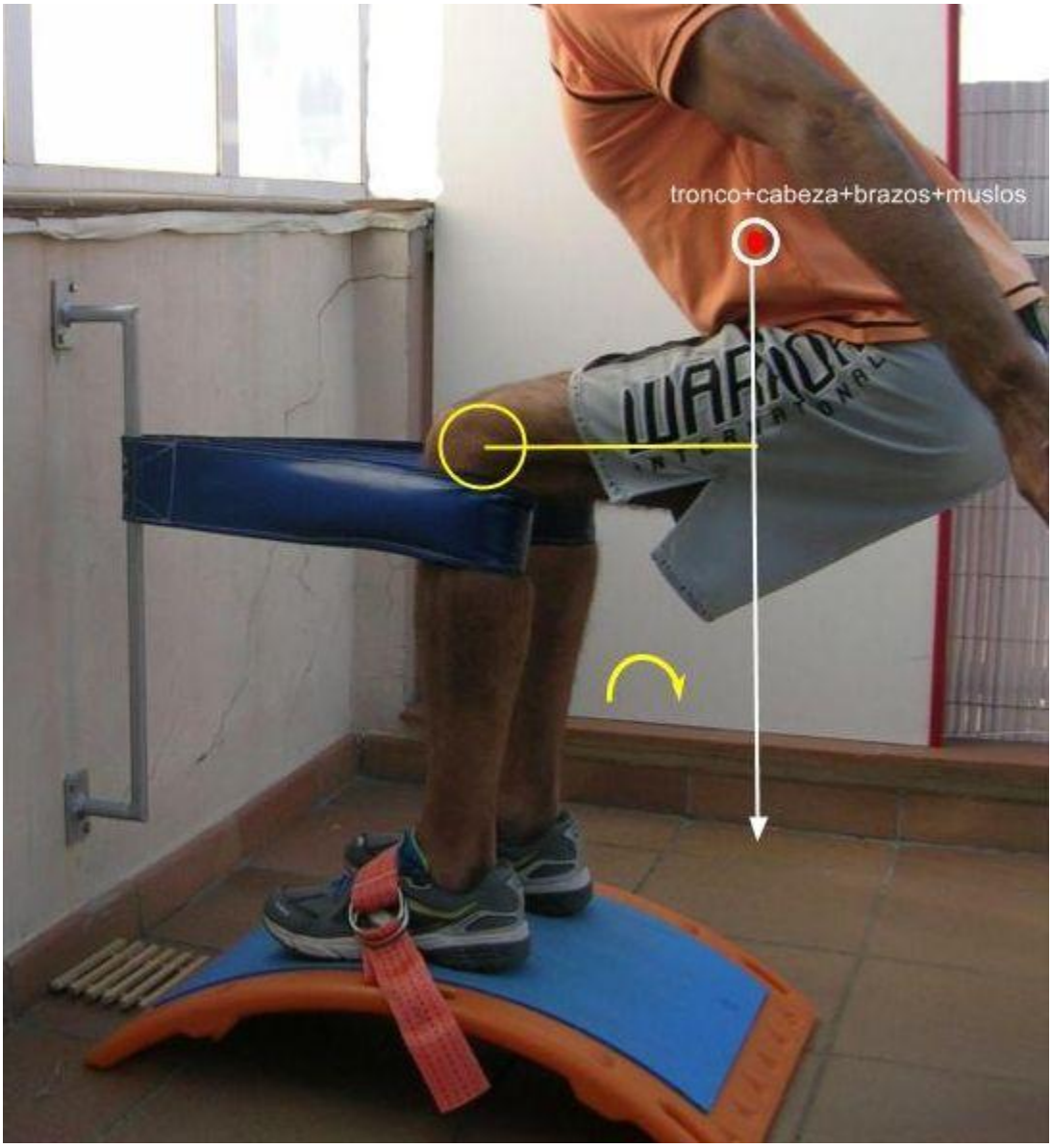
Squat a una pierna con apoyo en plano horizontal.

Squat a una pierna con apoyo en plano declinado.


tronco+cabeza+brazos


tronco+cabeza+brazos+muslos


tronco+cabeza+brazos


tronco+cabeza+brazos+muslos


tronco+cabeza+brazos
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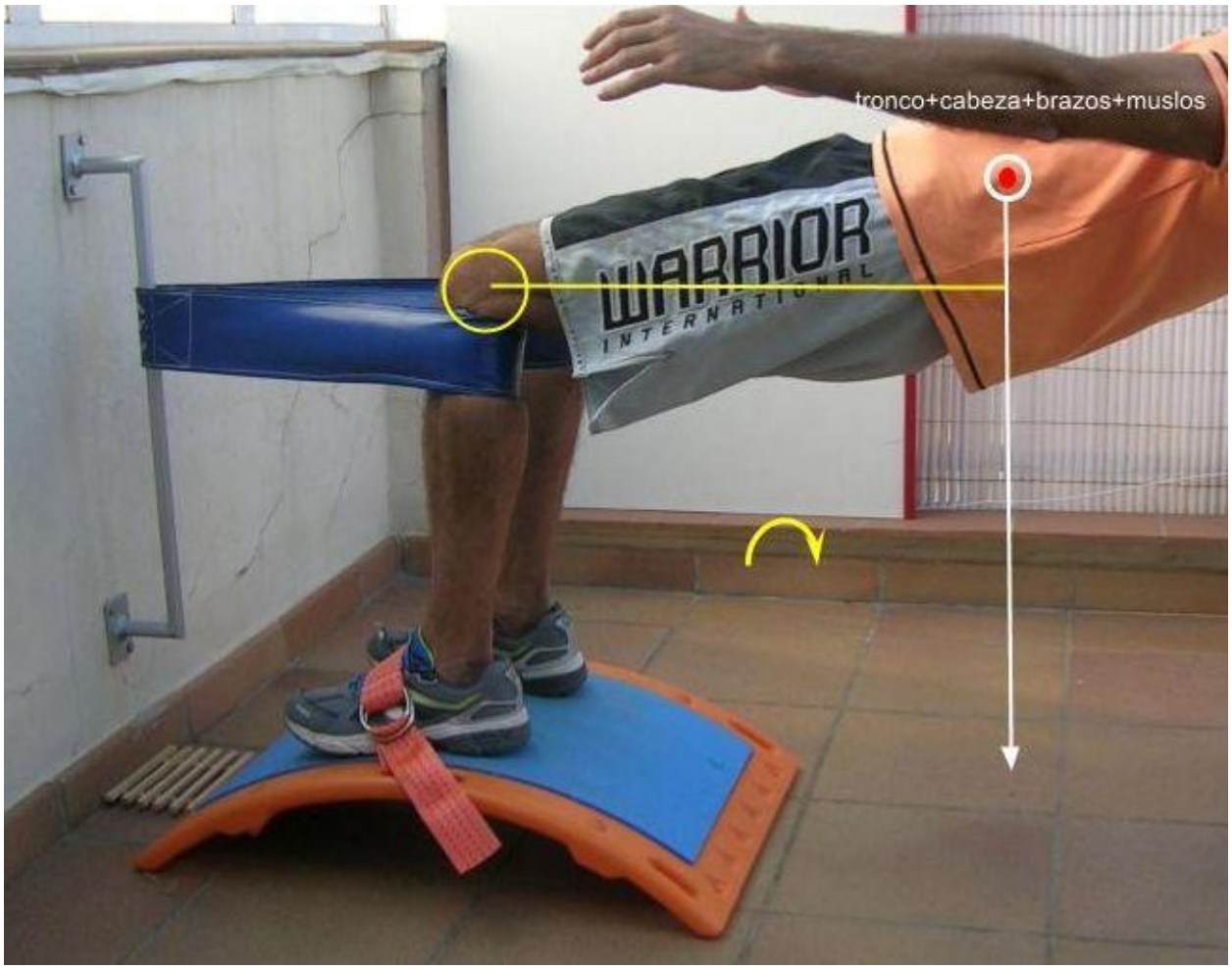
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